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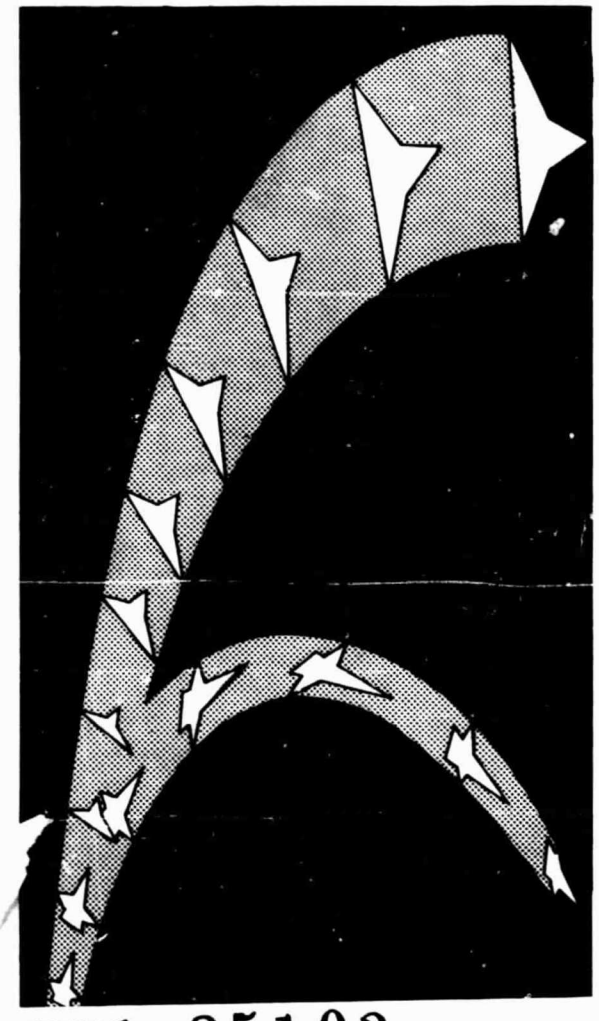
DMS-DR-1005



- SPACE SHUTTLE -

GAC III A CONFIGURATION EARTH ORBITING SHUTTLE EVALUATION OF LOW SPEED AERODYNAMIC CHARACTERISTICS

WIND TUNNEL TEST RESULTS
DATA REPORT
JULY 1970

CONTRACT NAS8-4016
SCHEDULE II
AMENDMENT 126
DRL 184-58

SADSAC SPACE SHUTTLE
AEROTHERMODYNAMIC
DATA MANAGEMENT SYSTEM

SPACE DIVISION CHRYSLER CORPORATION

TECHNICAL REPORT STANDARD TITLE PAGE

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NASA CR-103153		

4. TITLE AND SUBTITLE (Space Shuttle) GAC III A Configuration, Earth Orbiting Shuttle; Evaluation of Low Speed Aerodynamic Characteristics	5. REPORT DATE July 1970
	6. PERFORMING ORGANIZATION CODE CCSD
7. AUTHOR(S) S. Kalemaris, A. McBride and J. Wheeler, GAC	8. PERFORMING ORGANIZATION REPORT # DMS-DR-1005
9. PERFORMING ORGANIZATION NAME AND ADDRESS Chrysler Corporation Space Division Michoud Operations P.O. Box 29200 New Orleans, Louisiana 70129	10. WORK UNIT NO.
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12. SPONSORING AGENCY NAME AND ADDRESS National Aeronautics and Space Administration George C. Marshall Space Flight Center Marshall Space Flight Center, Alabama 35812	13. TYPE OF REPORT & PERIOD COVERED Contractor
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Contractor Monitor: C. Dale Andrews
Aero-Astrodynamics Laboratory

16. ABSTRACT

The test conducted in the GAC 7 x 10 foot Low Speed Wind Tunnel was designed to evaluate the low speed aerodynamic characteristics of the GAC III A configuration Earth Orbiting Shuttle and to determine whether a retractable wing would be required to provide sufficient lift for subsonic flight. The variables investigated were lower fuselage body flaps or speed brakes, different dihedral angles on the basic "V" tail, modifications to the tail and the fuselage near the tail. The wing was tested clean and with double slotted Fowler flaps deflected 45 and 55 degrees.

Canards, camber changes on the lower fuselage, and upper fuselage surface spoilers were evaluated as possible means of trimming the high negative pitching moment without producing the loss in lift and increase in drag that would result from negative elevator deflection.

Other variables investigated included the engines required for flight after reentry in the extended position and at various incidence angles, removable rocket nozzles, a cargo module on the upper fuselage surface to simulate a smaller shuttle with an external payload, and aft fuselage contour changes to reduce base drag.

Base pressure measurements were recorded, and a 45 probe rake was used to measure pressure recovery behind the main model support.

The ground board was installed for select runs to obtain some idea as to the order of magnitude of the ground effects, even though landing gear was not available for the model.

Contract No. NAS 8-4016 with Chrysler Corporation is for data presentation of information generated by various Space Shuttle Phase B contractors, and NASA Centers.

17. KEY WORDS	18. DISTRIBUTION STATEMENT
	U. S. Government Agencies and contractors only

19. SECURITY CLASSIF. (of this report)	20. SECURITY CLASSIF. (of this page)	21. NO. OF PAGES	22. PRICE
Unclassifed	Unclassified	27 Front 25 Data Plots 52 Total	

MSFC - Form 3292 (May 1969)

REPORT NUMBER: DMS-DR-1005

PUBLISHED: JULY, 1970

SPACE SHUTTLE
WIND TUNNEL TEST
DATA REPORT

TEST FACILITY: GRUMMAN 7 x 10 FT LOW SPEED WIND TUNNEL

CONFIGURATION: GAC III A CONFIGURATION EARTH ORBITING SHUTTLE

MODEL SCALE: 1/40

TEST PURPOSE: To Evaluate the Low Speed Aerodynamic Characteristics of the above Configuration

MACH NUMBER: 0.2

TESTS CONDUCTED BY:

GRUMMAN AIRCRAFT CORPORATION

TEST CONDUCTOR(S) S. Kalemaris

A. McBride; J. Wheeler

TEST DATE: 2-26 March 1970

CONTRACT REQUIREMENTS	CONTRACT ITEM	MODEL	CONTRACT NO.

REPORT

NO. GWTT 280 DATE: MARCH, 1970

DATA REPORT ON THE FIRST SERIES OF TESTS CONDUCTED ON A 1/40 SCALE MODEL OF THE GAC DESIGN 518 EARTH ORBITING SHUTTLE, CONFIGURATION III A IN THE 7 x 10 FOOT GRUMMAN LOW SPEED WIND TUNNEL.

CODE 26512

PREPARED BY: A. MC BRIDE/J. WHEELER TECHNICAL APPROVAL:

CHECKED BY: APPROVED BY:

DEPARTMENT: ENGINEERING APPROVED BY:

SECTION: AERO TEST APPROVED BY:

REVISIONS

DATE	REV. BY	REVISIONS & ADDED PAGES	REMARKS

FORM C324 REV 1 8-64 QR 1642

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INTRODUCTION

This test constituted the first series of tests conducted on a 1/40 scale model of the GAC III A configuration Earth Orbiting Shuttle in the Grumman 7 x 10 ft. Low Speed Wind Tunnel. These tests were conducted from March 2 to March 26, 1970. The cognizant engineering personnel were:

S. Kalemaris - Aerodynamics

A. McBride - Aero Test

J. Wheeler - Aero Test

SUMMARY

The test conducted in the GAC 7 x 10 foot Low Speed Wind Tunnel was designed to evaluate the low speed aerodynamic characteristics of the GAC III A configuration Earth Orbiting Shuttle and to determine whether a retractable wing would be required to provide sufficient lift for subsonic flight. The variables investigated were lower fuselage body flaps or speed brakes, different dihedral angles on the basic "V" tail, modifications to the tail and the fuselage near the tail. The wing was tested clean and with double slotted Fowler flaps deflected 45 and 55 degrees.

Canards, camber changes on the lower fuselage, and upper fuselage surface spoilers were evaluated as possible means of trimming the high negative pitching moment without producing the loss in lift and increase in drag that would result from negative elevator deflection.

Other variables investigated included the engines required for flight after reentry in the extended position and at various incidence angles, removable rocket nozzles, a cargo module on the upper fuselage surface to simulate a smaller shuttle with an external payload, and aft fuselage contour changes to reduce base drag.

Base pressure measurements were recorded, and a 45 probe rake was used to measure pressure recovery behind the main model support.

The ground board was installed for select runs to obtain some idea as to the order of magnitude of the ground effects, even though landing gear was not available for the model.

DATA REDUCTION

The data from the six component mechanical balance was transferred to a nominal cg located at FS 1016 (59.4% fuselage length; nose at FS 0), WL 280 (FRL is at WL 300), and BL 0; which is 7.65" aft of and on the same WL and BL as the trunnion pin. The following is a list of model constants used for data reduction:

S_{REF} (model planform area) = 3.9375 ft.^{2}

ℓ_{REF} (model length) = 3.5625 ft.

b_{REF} (model span) = 2.100 ft.

The data was corrected theoretically for tunnel blockage and wall effects and experimentally for model support tare and interference effects and tunnel flow angularity. These data corrections are on file in the Aero Test Department

DESCRIPTION OF TUNNEL

The Grumman wind tunnel is an open return, closed throat, Venturi type tunnel having a 7 x 10 ft. rectangular test section.

The rectangular entrance section is equipped with radially faired entrance fairings to give a bell-mouth effect. A honeycomb is located in the entrance section to provide flow straightening, and fine mesh copper screening has been added forward and aft of the honeycomb to smooth out flow pulsations.

A smoothly faired contraction cone connects the entrance section to the test section. Corner fairings begin at the start of the contraction cone and gradually increase in size until they enter the test section. The corner fairings in the test section are given a slight downstream divergence to reduce bouyancy effects.

The diffuser section changes from rectangular at the end of the test section to square at the beginning of the transition section, while the transition section smoothly fairs into a circular section at the propeller ring.

The test section will accommodate models up to an eight foot wing span. The tunnel may be operated at any speed up to 160 mph. Most testing is conducted at a tunnel speed of approximately 140 mph. At this speed, the motor is delivering approximately 1200 H.P.,
giving the tunnel an energy ratio of 1.0.

The balance system measures all forces applied to the model up to the following capacities: Lift, + 4000 lbs. - 2000 lbs.; drag and side force + 500 lbs.; pitching, rolling and yawing moments ± 1200 ft.-lbs.

TEST CONDITIONS
TEST GWTT 280

MACH NUMBER	REYNOLDS NUMBER per unit length	DYNAMIC PRESSURE (pounds/sq. inch)	STAGNATION TEMPERATURE (degrees Fahrenheit)
.2	1.59×10^6	.278	70°

BALANCE UTILIZED: PYRAMID L.S.W.T. BALANCE

	CAPACITY:	ACCURACY:	COEFFICIENT TOLERANCE:
NF	+ 4000 lb-2000lb.	± .5	± .002
SF	± 500 lbs.	± .2	± .001
AF	± 500 lbs	± .2 lbs	± .0005
PM	± 1200 ft-lbs	± 1 ft-lb	± .005
YM	± 1200 ft-lbs	± 1 ft-lb	± .005
RM	± 1200 ft-lbs	± 1 ft-lb	± .005

COMMENTS:

CONFIGURATIONS INVESTIGATED

CONFIGURATION

NOMENCLATURE

B = Body

N = Nozzle

T = "V" tail

The following pages give dimensional data on the above components.

Combinations Tested

B_{301}, N_{301}

B_{301} N_{301} $T_{1,50}$

MODEL COMPONENT: BODY - (B_{301})

GENERAL DESCRIPTION: Basic design 518 -III A configuration of the 1/40 scale Earth Orbiting Shuttle.

DRAWING NUMBER: 518 MOD 320

DIMENSIONS:	FULL-SCALE	MODEL SCALE
Length	142.46 ft.	13.15 in.
Max. Width		
Max. Depth		
Fineness Ratio	4.73	4.73
Area		
Max. Cross-Sectional	892 ft.^{2}	0.557 ft.^{2}
Planform	6120 ft.^{2}	3.83 ft.^{2}
Wetted		
Base		

MODEL COMPONENT: Vertical Tail ($T_{1.50}$)

GENERAL DESCRIPTION: 518 III A design "V" tail of the 1/40 scale Earth Orbiting Shuttle . Subscript 50 denotes dihedral angle.

DRAWING NUMBER: 518 MOD 331

DIMENSIONS: (EXPOSED)	FULL-SCALE	MODEL SCALE
Area	535 ft.^{2}	160.5 in.^{2}
Span (equivalent)	26.2 ft.	7.8 in.
Inb'd equivalent chord		
Outb'd equivalent chord		
Ratio Elevator chord/horizontal tail chord		
At Inb'd equiv. chord		
At Outb'd equiv. chord		
Sweep Back Angles, degrees		
Leading Edge	53.9°	53.9°
Tailing Edge		
Hingeline		
Area Moment (Normal to hinge line)		
Airfoil Section	NACA 63A010	

TEST GWTT 280 DATA SET COLLATION SHEET

δ_R = RUDDER DEFLECTION
δ_{VT} = "V" TAIL DIHEDRAL

α A = 1
α B = 2
α C = 3

βA = 7

☐ PRETEST
☒ POSTTEST

DATA SET IDENTIFIER	CONFIGURATION	SCHD. α	SCHD. β	CONTROL DEFLECTION δ_R	CONTROL DEFLECTION δ_{VT}			NO. of RUNS	MACH NUMBERS .2											
RC3012	B301 N301 $T_{1,50}$	B	0	0	50				10											
RC3022		B	5	0	50				12											
RC3037		0	A	0	50				16											
RC3047		10	A	0	50				18											
RC3057	↓	20	A	0	50				20											
RC3062	B_{301} N_{301}	B	5	-	-				14											
RC3077		20	A	-	-				22											
RC3087		10	A	-	-				24											
RC3097		0	A	-	-				26											
RC3101	↓	A	0	-	-				8											

1 7 13 19 25 31 37 43 49 55 61

COEFFICIENTS: CL CD CY CNM CYM CRL

α or β SCHEDULES

α A = -10 to 30° BY 4° (PS), BY 2° (P) β A = +10 TO -4° BY 4° (YS), 2°(Y)
α B = -4 TO 30° BY 4° (PS), BY 2° (P)
α C = -4 to 16° BY 4°

PS=WIND OFF PITCH(STATIC) NDV
P = WIND ON PITCH
YS = YAW STATIC
Y = WIND ON YAW

TEST GWTT 280 DA \ SET DESCRIPTOR SHEET

DATA SET IDENTIFIER	DATA SET DESCRIPTOR (1 / 11 / 21 / 31 / 41)		CURVE SLOPE RANGE (51) LOWER LIMIT	(61) UPPER LIMIT
RC3012	GWTT 280 - GAC - EARTH ORBITER -B 301 N 301 T 1,50	11		
RC3022		11		
RC3037		21		
RC3047		21		
RC3057	B301 N301 T 1,50	21		
RC3062	B301 N301	11		
RC3077		21		
RC3087		21		
RC3097		21		
RC3101	GWTT 280-GAC- EARTH ORBITER - B301 N301	11		

1 / 11 / 21 / 31 / 41 / 51 / 61

REFERENCE AREA S_R	LONGITUDINAL ℓ_R	LATERAL b_R	LONGITUDINAL XMRP	LATERAL YMRP	VERTICAL ZMRP	SOURCE DOCUMENT
3.9375 ft^2	3.5625 ft	2.100 ft.	0.690 ft	0	0.0858FT.	
REFERENCE LENGTH			MOMENT REFERENCE POINT			

NOMENCLATURE

SYMBOL	SADSAC SYMBOL	DEFINITION
A_b		base area; m^2, ft^2, in^2
a		speed of sound; m/sec, ft/sec
AR	ASPECT	aspect ratio, b^2/S
b	REFB	wing span or reference span; m, ft, in
c		wing chord; m, ft, in
$\bar{c}$		wing mean aerodynamic chord or reference chord; m, ft, in
c. g.		center of gravity
C. P.		center of pressure
C_A	CATOTL	axial force coefficient, $F_A/q\,S_{ref}$
C_{A_b}	CABASE	base axial force coefficient, $[(p_\infty - p_b/q]$ (A_b/S_{ref})
C_{A_f}	CAFORE	forebody axial force coefficient, $C_A - C_{A_b}$
C_D	CDTOTL	drag force coefficient in the wind axis system, $F_D/q\,S_{ref}$
C_D'	CD	drag force coefficient in the stability axis system, $F_D'/q\,S_{ref}$
C_L	CL	lift force coefficient (stability or wing axis) $F_L/q\,S_{ref}$
C_ℓ	CRL	rolling moment coefficient in body axis system, $M_x/q\,S_{ref}\,b$
$C_{\ell,s}$	CSL	rolling moment coefficient in the stability axis system, $M_{x,s}/q\,S_{ref}\,b$
$C_{\ell,w}$	CWL	rolling moment coefficient in the wind axis system, $M_{x,w}/q\,S_{ref}\,b$

NOMENCLATURE (Continued)

SYMBOL	SADSAC SYMBOL	DEFINITION
C_m	CNM	pitching moment coefficient in the body axis system, $M_y/q\ S_{ref}\ \ell_{ref}$
$C_{m,s}$	CNM	pitching moment coefficient in the stability axis system, $C_{m,s} = C_m$
$C_{m,w}$	CWM	pitching moment coefficient in the wind axis system, $M_{y,w}/q\ S_{ref}\ \ell_{ref}$
C_N	CN	normal force coefficient in the body axis system, $F_N/q\ S_{ref}$
C_n	CYM	yawing moment coefficient in the body axis system, $M_z/q\ S_{ref}\ b$
$C_{n,s}$	CWN	yawing moment coefficient in the stability axis system, $C_{n,s} = C_n$
$C_{n,w}$	CWN	yawing moment coefficient in the wind axis system, $M_{z,w}/q\ S_{ref}\ b$
C_p	CP	pressure coefficient, $(p - p_\infty)/q$
C_y	CY	side force coefficient (body or stability axis system), $F_y/q\ S_{ref}$
F_A		axial force; N, lb
F_D		drag force in wind axis system; N, lb
F_D'		drag force in the stability axis system; N, lb
F_L		lift force (stability or wind axis system); N, lb
F_N		normal force; N, lb
F_Y		side force; N, lb
ℓ_{ref}	REFL	reference length ; m, ft, in
L/D	L/D	lift-to-drag ratio, C_L/C_D
M	MACH	Mach number

NOMENCLATURE (Continued)

SYMBOL	SADSAC SYMBOL	DEFINITION
MRP	MRP	abbreviation for moment reference point
M_x		rolling moment in the body axis system; N-m, ft-lb
$M_{x,s}$		rolling moment in the stability axis system; N-m, ft-lb
$M_{x,w}$		rolling moment in the wind axis system; N-m, ft-lb
M_y		pitching moment in the body (or stability) axis system; N-m, ft-lb
$M_{y,w}$		pitching moment in the wind axis system; N-m, ft-lb
M_z		yawing moment in the body axis system; N-m, ft-lb
$M_{Z,w}$		yawing moment in the wind axis system; N-m, ft-lb
p		static pressure; N/m^2; psi
P		total pressure; N/m^2; psi
q	Q(PSI) Q(PSF)	dynamic pressure; N/m^2, psi, psf
RN/L	RN/L	Reynold's number per unit length; million/ft.
S		characteristic area; m^2, ft^2
S_{ref}	REFS	reference area; m^2, ft^2
T		temperature; ^oK, ^oC, ^oR, ^oF
V		speed of vehicle relative to surrounding atmosphere; m/sec, ft/sec

NOMENCLATURE (Continued)

SYMBOL	SADSAC SYMBOL	DEFINITION
$\bar{V}$		velocity of vehicle relative to surrounding atmosphere; m/sec, ft/sec
α	ALPHA	angle of attack, angle between the projection of the wind X_W-axis on the body X, Z - plane and the body X-axis; deg
β	BETA	sideslip angle, angle between the wind X_W-axis and the projection of this axis on the body X-Z-plane; deg
γ		ratio of specific heats
Γ	DIHDRL	wing dihedral angle; deg
δ		control surface deflection angle; deg positive deflections are: aileron - left aileron trailing edge down elevator - trailing edge down rudder - trailing edge to the left flap - trailing edge down tab - trailing edge down with respect to control surface
ρ		air density; K_g/m^3, slugs/ft^3
θ		pitch angle, angle of rotation about the body Y-axis, positive when the positive Z-axis is rotated toward the positive X-axis; deg
ϕ	PHI	roll angle, angle of rotation about the body X-axis, positive when the positive Y-axis is rotated toward the positive Z-axis; deg
ψ	PSI	yaw angle, angle of rotation about the body Z-axis, positive when the positive X-axis is rotated toward the positive Y-axis; deg

NOMENCLATURE (Continued)

SUBSCRIPTS	DEFINITION
a	aileron
b	base
c	canard
e	elevator or elevon
f	flap
r	rudder or ruddervator
s	stability axis system
t	tail, or total conditions
w	wind axis system
ref	reference conditions

FIGURES

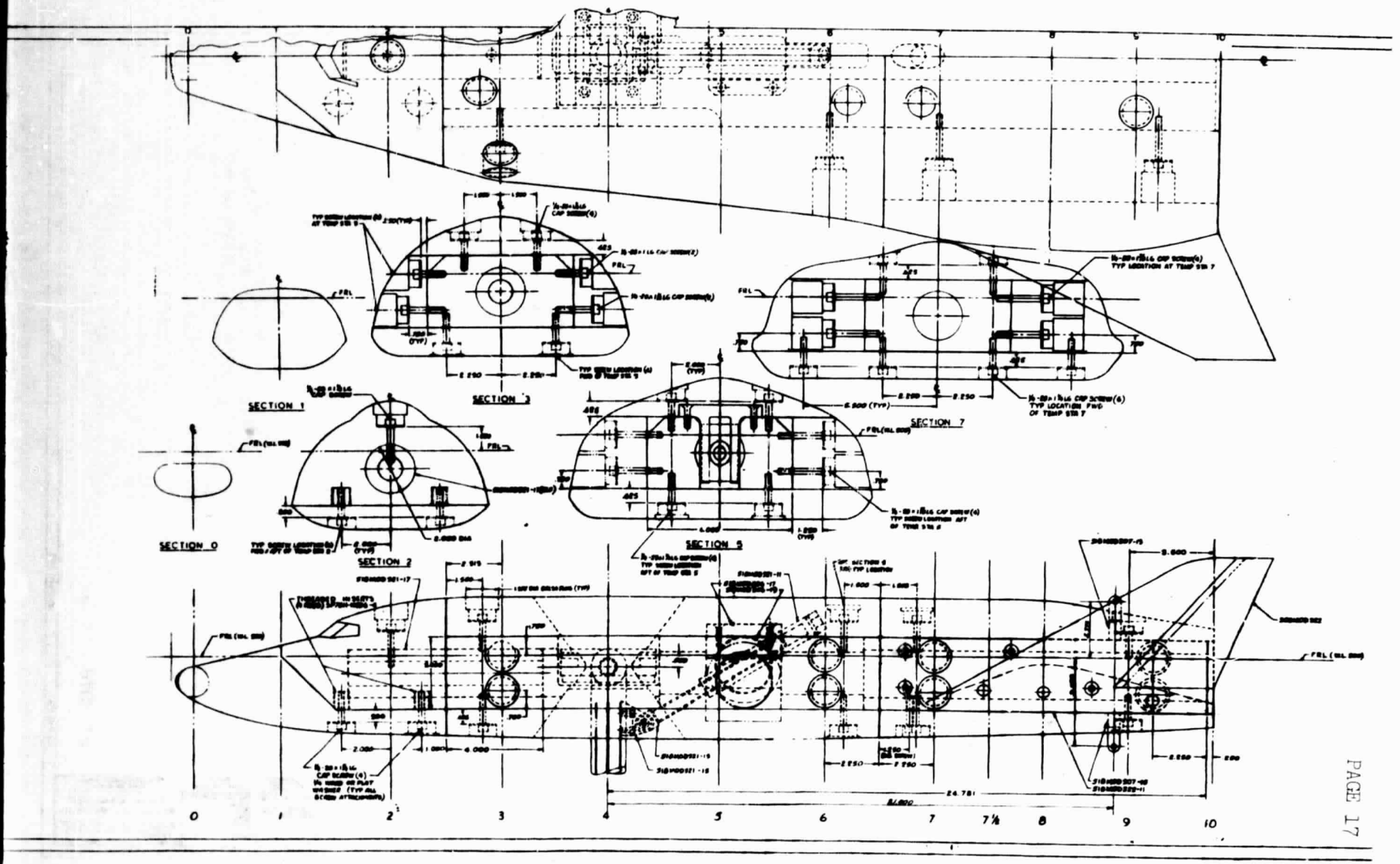
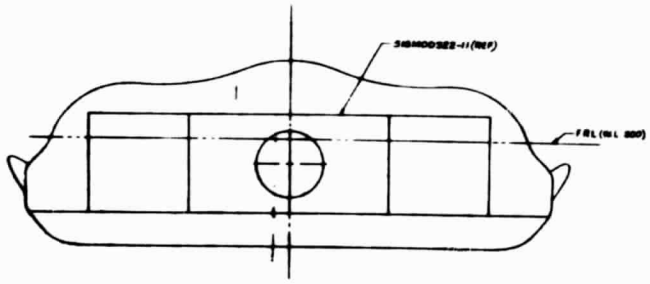


FIGURE 1. GENERAL ARRANGEMENT DRAWING OF 1/40 SCALE EARTH ORBITER-III A 518 MOD 320



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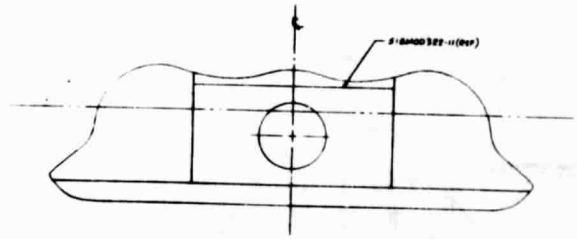
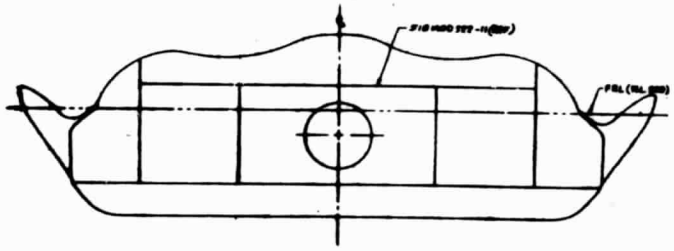
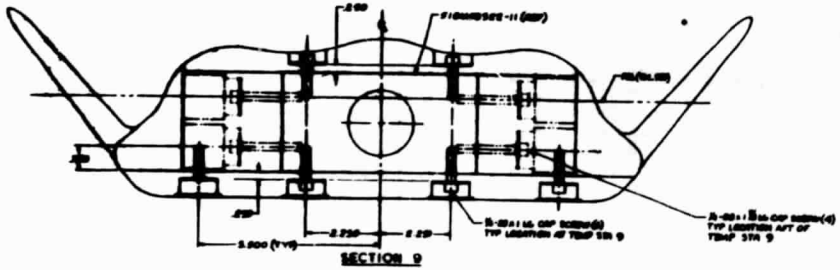


SECTION 10



SECTION 8



SECTION 9

GENERAL ARRANGEMENT

518MOD320

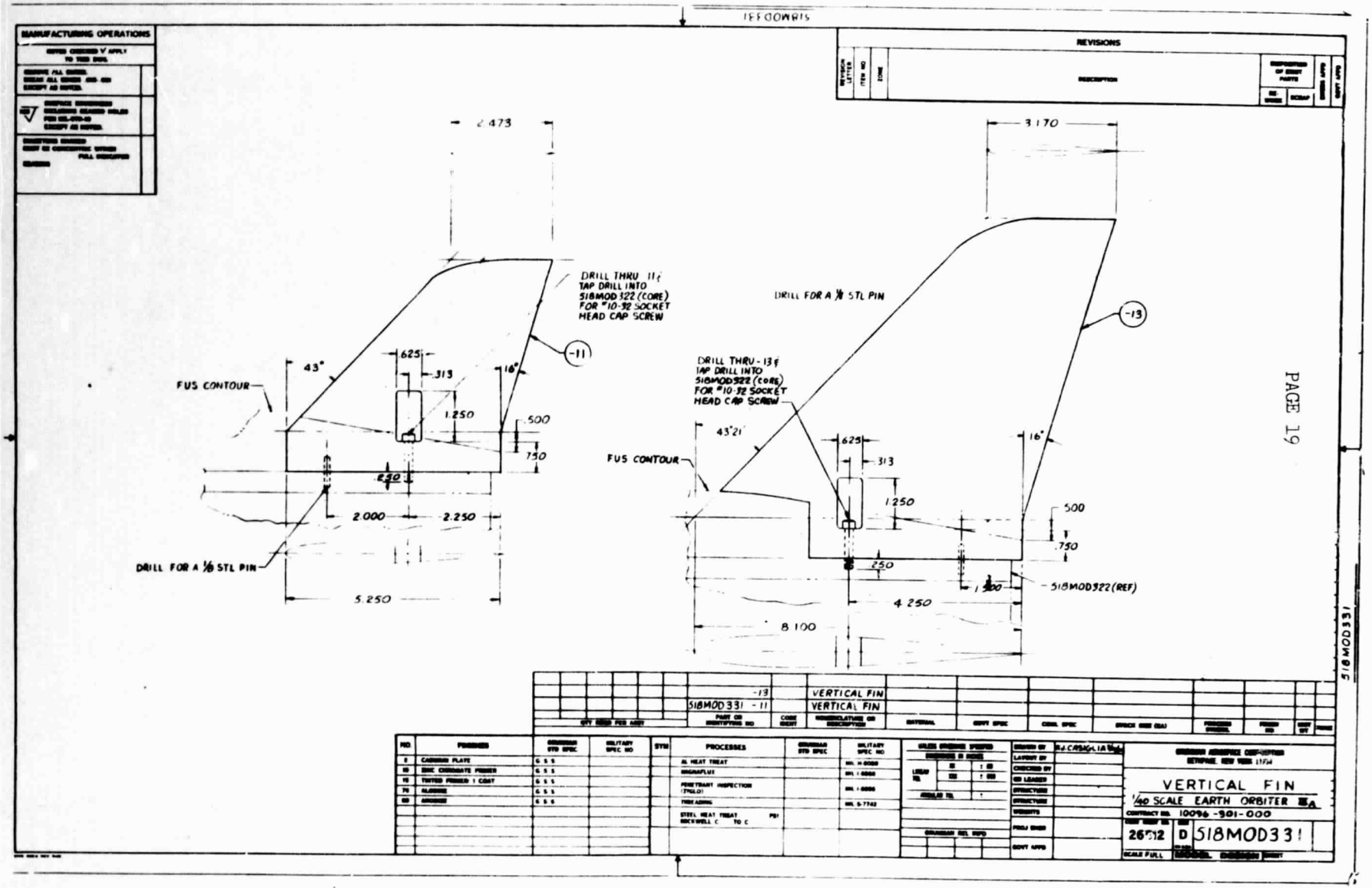


FIGURE 2. VERTICAL FIN - 518 MOD 331

PHOTOGRAPHS

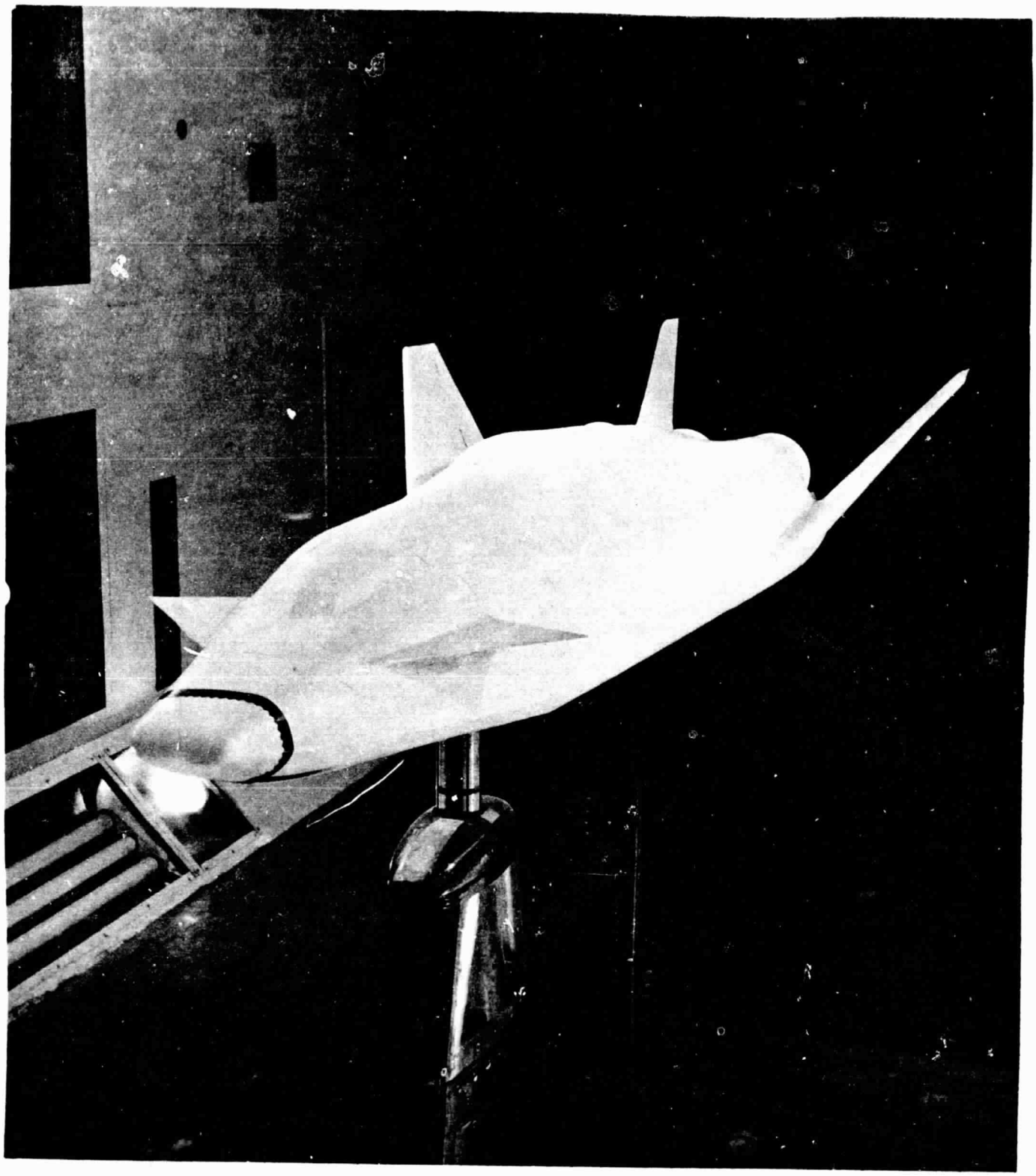


FIGURE 3. MODEL INSTALLATION PHOTO

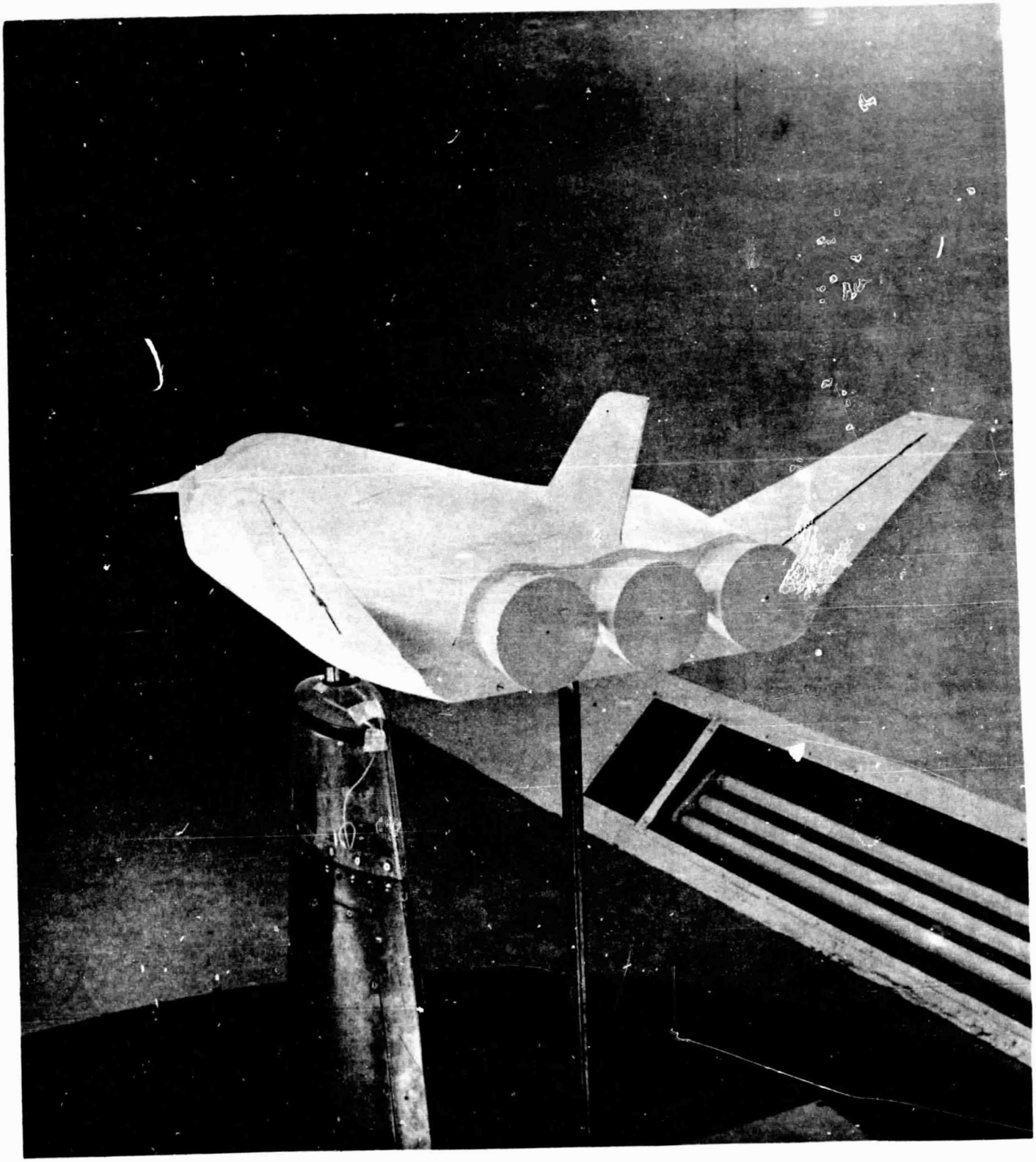


FIGURE 4. MODEL INSTALLATION PHOTO

DATA DISPLAY INDEX

DATA DISPLAY INDEX

I. Multiple, Dependent Variables vs. Angular Variation

Data Set Identifier		Data Begins on Plot Page
RC3101	RC3012	1
BC3101	BC3012	4
AC3101	AC3012	6
RC3062	RC3022	7
BC3062	BC3022	10
AC3062	AC3022	12
RC3097	RC3037	13
RC3087	RC3047	16
RC3077	RC3057	19

R Data Set Dependent Variables - CL, CD, CNM or CY, CYM, CRL
B Data Set Dependent Variables - CN, CATOTL
A Data Set Dependent Variable - L/D

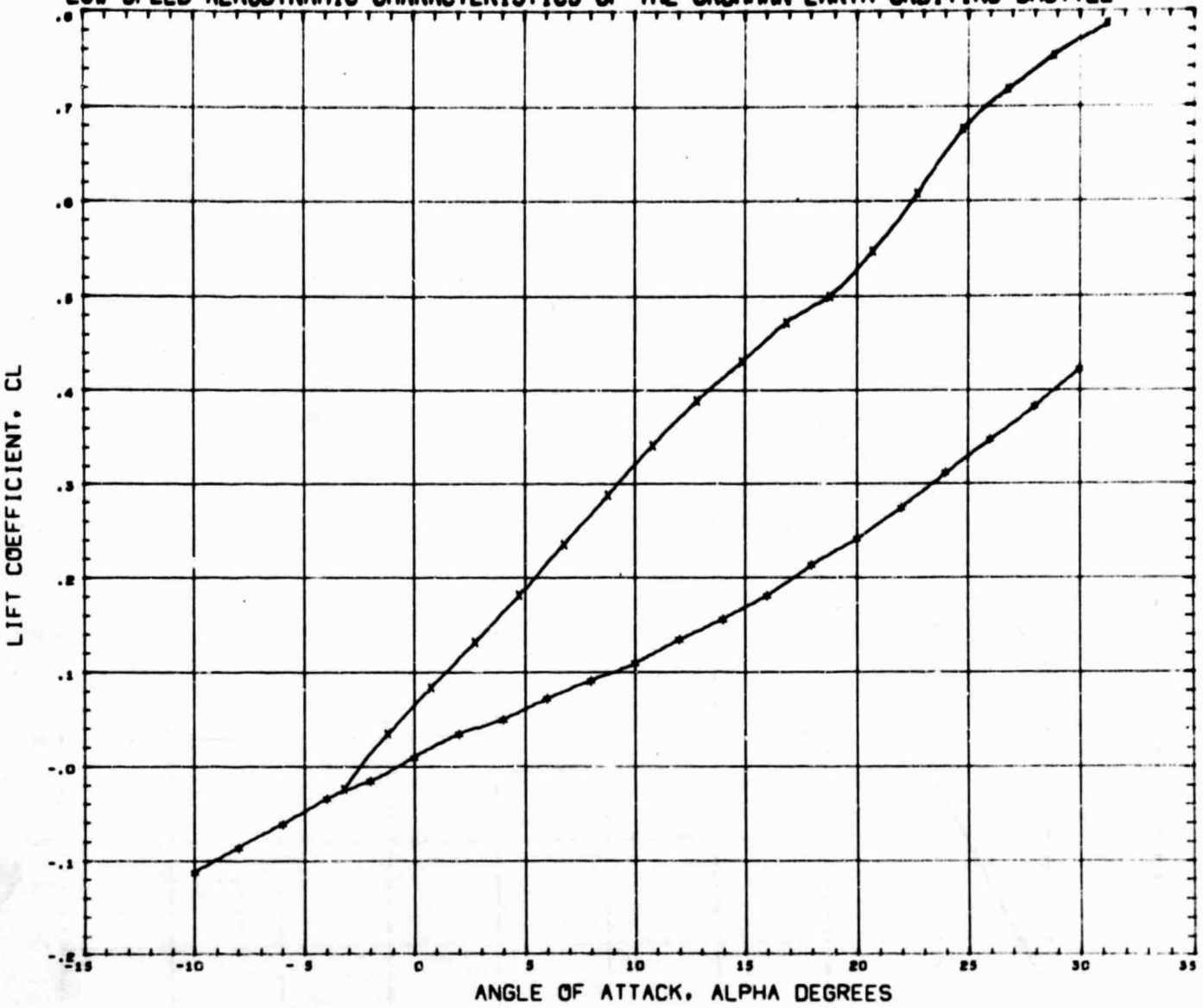
II. Multiple, dependent Variable, Cross-Plots

Data Set Identifier		Data Begins on Plot Page
RC3101	RC3012	22
RC3062	RC3022	24

Dependent Variable Cross-Plots - CL vs. CD, CNM vs. CL

DATA

LOW SPEED AERODYNAMIC CHARACTERISTICS OF THE GRUMMAN EARTH ORBITING SHUTTLE



SYMBOL	CONFIGURATION DESCRIPTION	DATA SET	DATE	MACH
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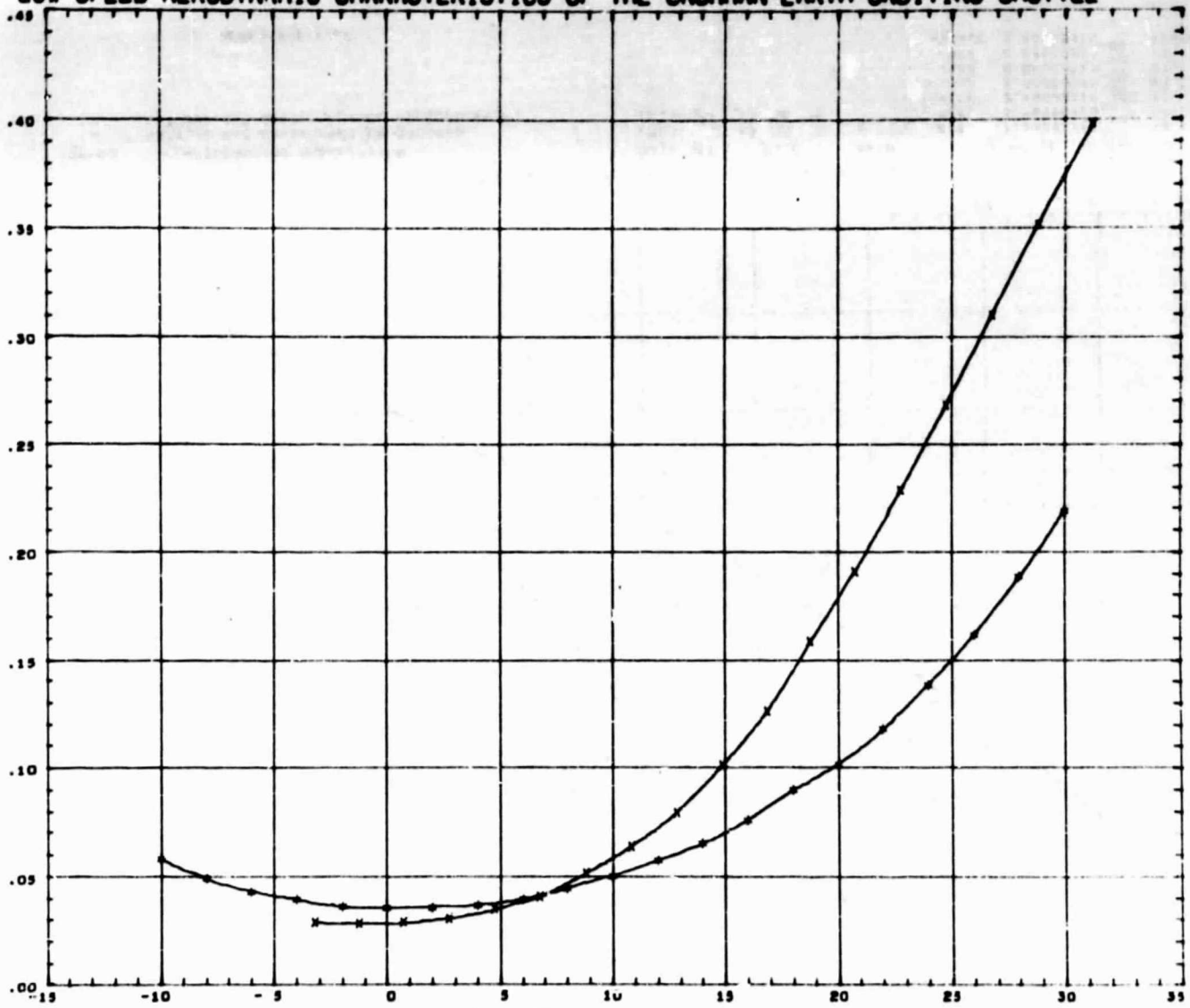
X	GWTT280 GAC EARTH ORBITER-B301N301T1,50	(RC3012)	13 JUL 70	

REFERENCE INFORMATION

REFS	3.93750X10^{+00}	SQ.FT.
REFL	3.56250X10^{+00}	FT.
REFB	2.10000X10^{-01}	FT.
XMRP	6.90000X10^{+00}	FT.
YMRP	0.00000X10^{-02}	FT.
ZMRP	8.58000X10^{-02}	FT.
SCALE	2.50000X10	1/40TH

REFERENCE FILE

LOW SPEED AERODYNAMIC CHARACTERISTICS OF THE GRUMMAN EARTH ORBITING SHUTTLE



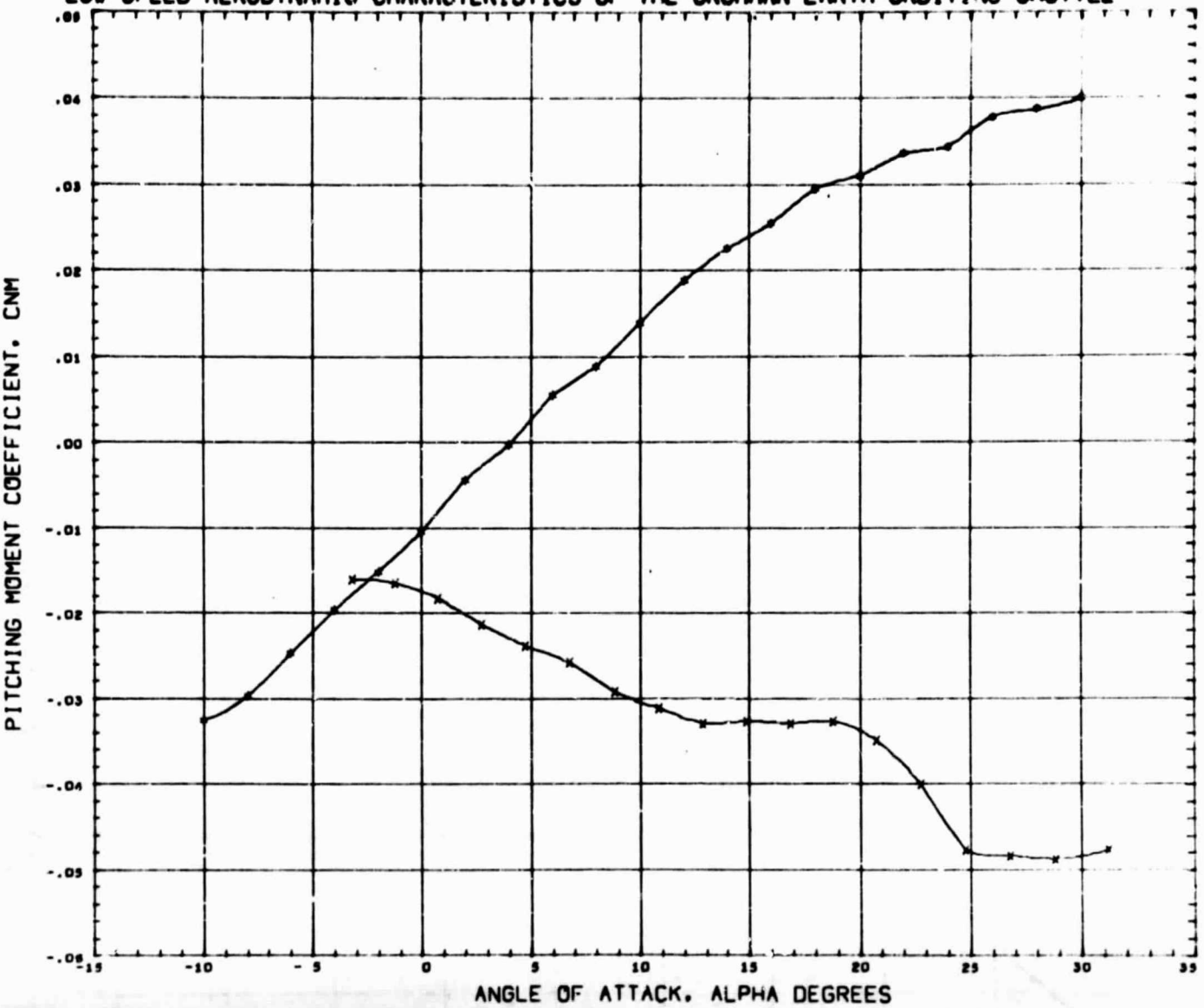
SYMBOL	CONFIGURATION DESCRIPTION	DATA SET	DATE	MACH
*	GWTT28D GAC EARTH ORBITER-B301N301	(RC3101)	13 JUL 70	0.200
X	GWTT28D GAC EARTH ORBITER-B301N301T1,50	(RC3012)	13 JUL 70	

REFERENCE INFORMATION

REFS	3.93750X10^{+00}	50.FT.
REFL	3.56250X10^{+00}	FT.
REFB	2.10000X10^{-01}	FT.
XMRP	6.90000X10^{+00}	FT.
YMRP	0.00000X10^{-02}	FT.
ZMRP	8.58000X10^{-02}	FT.
SCALE	2.50000X10	1/40TH

REFERENCE FILE

LOW SPEED AERODYNAMIC CHARACTERISTICS OF THE GRUMMAN EARTH ORBITING SHUTTLE

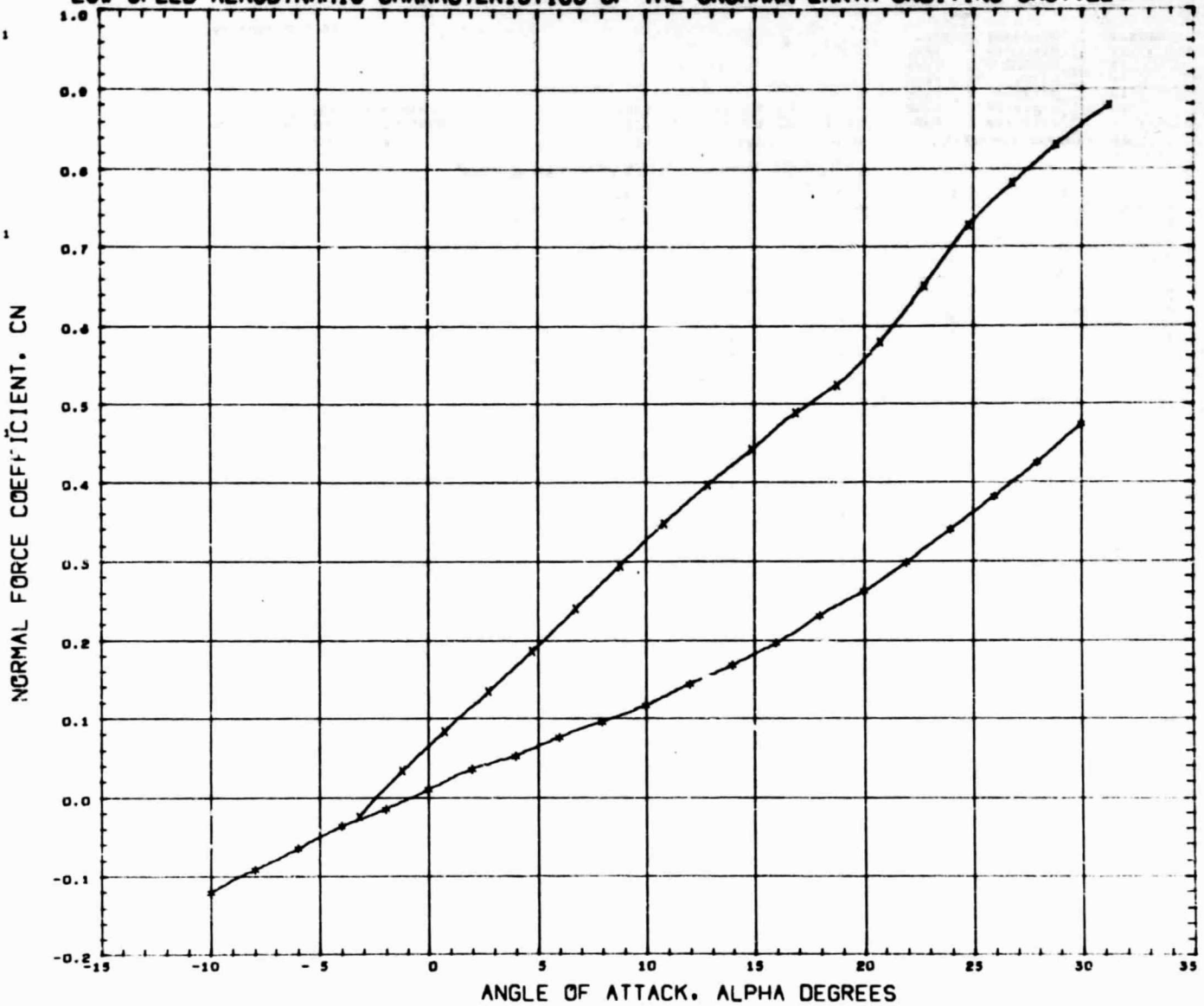


SYMBOL	CONFIGURATION DESCRIPTION	DATA SET	DATE	MACH
*	GWTT280 GAC EARTH ORBITER-B301N301	(RC3101)	13 JUL 70	0.200
x	GWTT280 GAC EARTH ORBITER-B301N301T1,50	(RC3012)	13 JUL 70	

REFERENCE FILE

REFERENCE INFORMATION		
REFS	3.93750X10^{+00}	SQ.FT.
REFL	3.56250X10^{+00}	FT.
REFB	2.10000X10^{-01}	FT.
XMRP	6.90000X10^{+00}	FT.
YMRP	0.00000X10^{-02}	FT.
ZMRP	8.58000X10^{-02}	FT.
SCALE	2.50000X10	1/4GTH

LOW SPEED AERODYNAMIC CHARACTERISTICS OF THE GRUMMAN EARTH ORBITING SHUTTLE



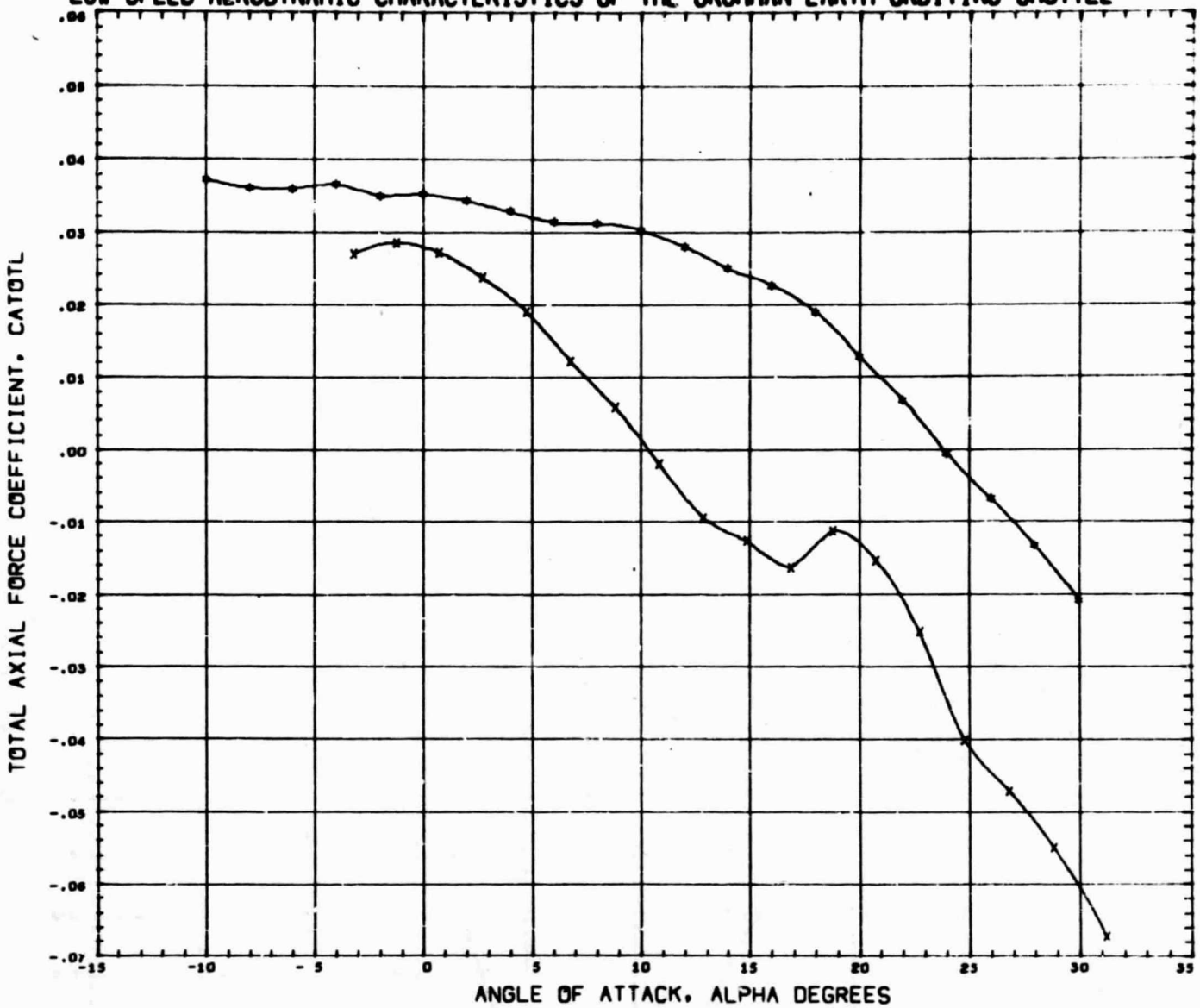
SYMBOL	CONFIGURATION DESCRIPTION	DATA SET	DATE	MACH
*	GWTT280 GAC EARTH ORBITER-B301N301	(BC3101)	13 JUL 70	0.200
x	GWTT280 GAC EARTH ORBITER-B301N301T1,50	(BC3012)	13 JUL 70	

REFERENCE INFORMATION

REFS	3.93750X10^{+00}	SQ.FT.
REFL	3.56250X10^{+00}	FT.
REFB	2.10000X10^{-01}	FT.
XMRP	6.90000X10^{+00}	FT.
YMRP	0.00000X10^{-02}	FT.
ZMRP	8.58000X10^{-02}	FT.
SCALE	2.50000X10	1/40TH

REFERENCE FILE

LOW SPEED AERODYNAMIC CHARACTERISTICS OF THE GRUMMAN EARTH ORBITING SHUTTLE



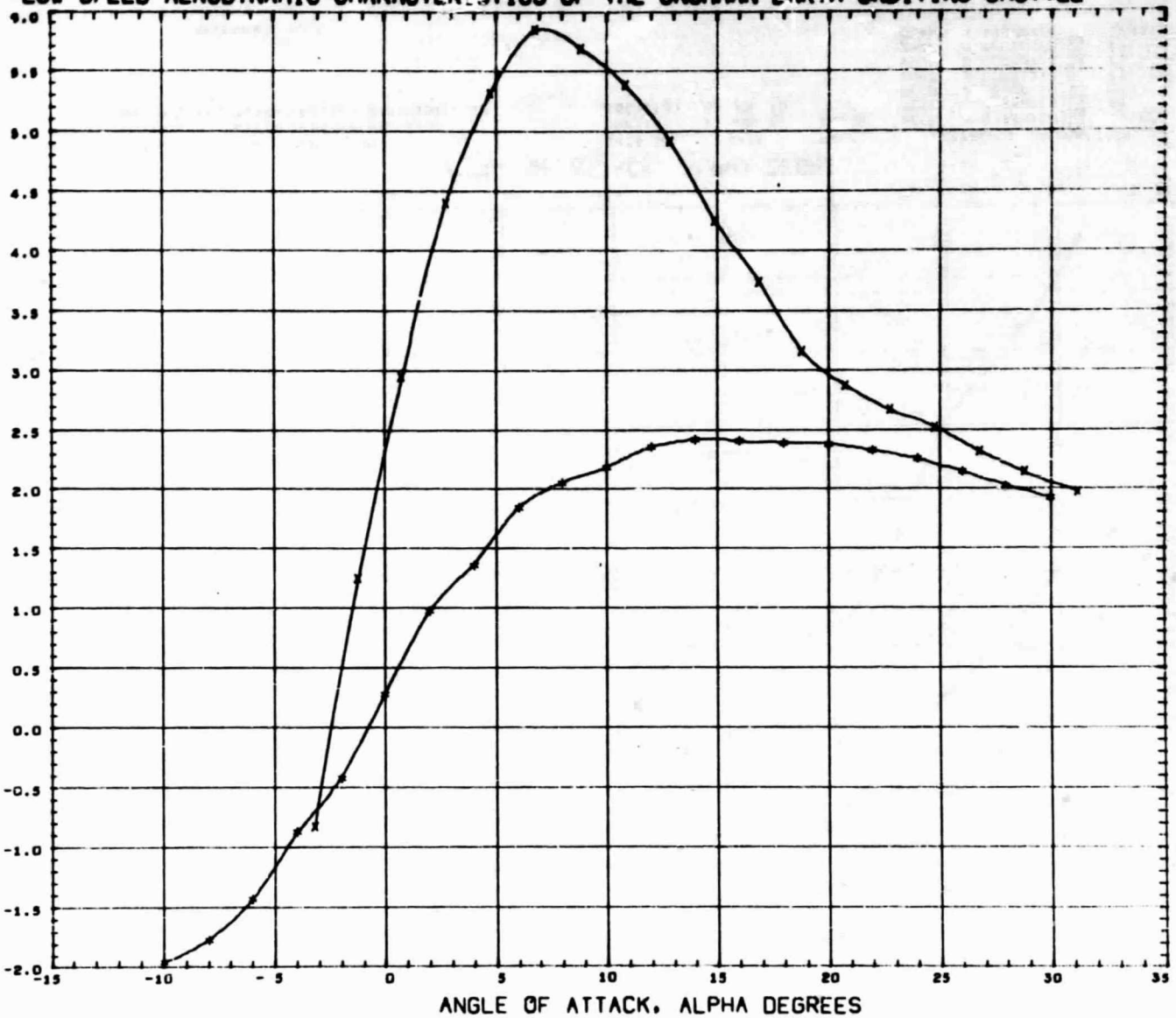
SYMBOL	CONFIGURATION DESCRIPTION	DATA SET	DATE	MACH
*	GWTT280 GAC EARTH ORBITER-B301N301	(BC3101)	13 JUL 70	0.200
X	GWTT280 GAC EARTH ORBITER-B301N301T1,50	(BC3012)	13 JUL 70	

REFERENCE INFORMATION

REFS	3.93750X10+00	SQ.FT.
REFL	3.56250X10+00	FT.
REFB	2.10000X10-01	FT.
XMRP	6.90000X10+00	FT.
YMRP	0.00000X10-02	FT.
ZMRP	8.58000X10-02	FT.
SCALE	2.50000X10	1/40TH

REFERENCE FILE

LOW SPEED AERODYNAMIC CHARACTERISTICS OF THE GRUMMAN EARTH ORBITING SHUTTLE



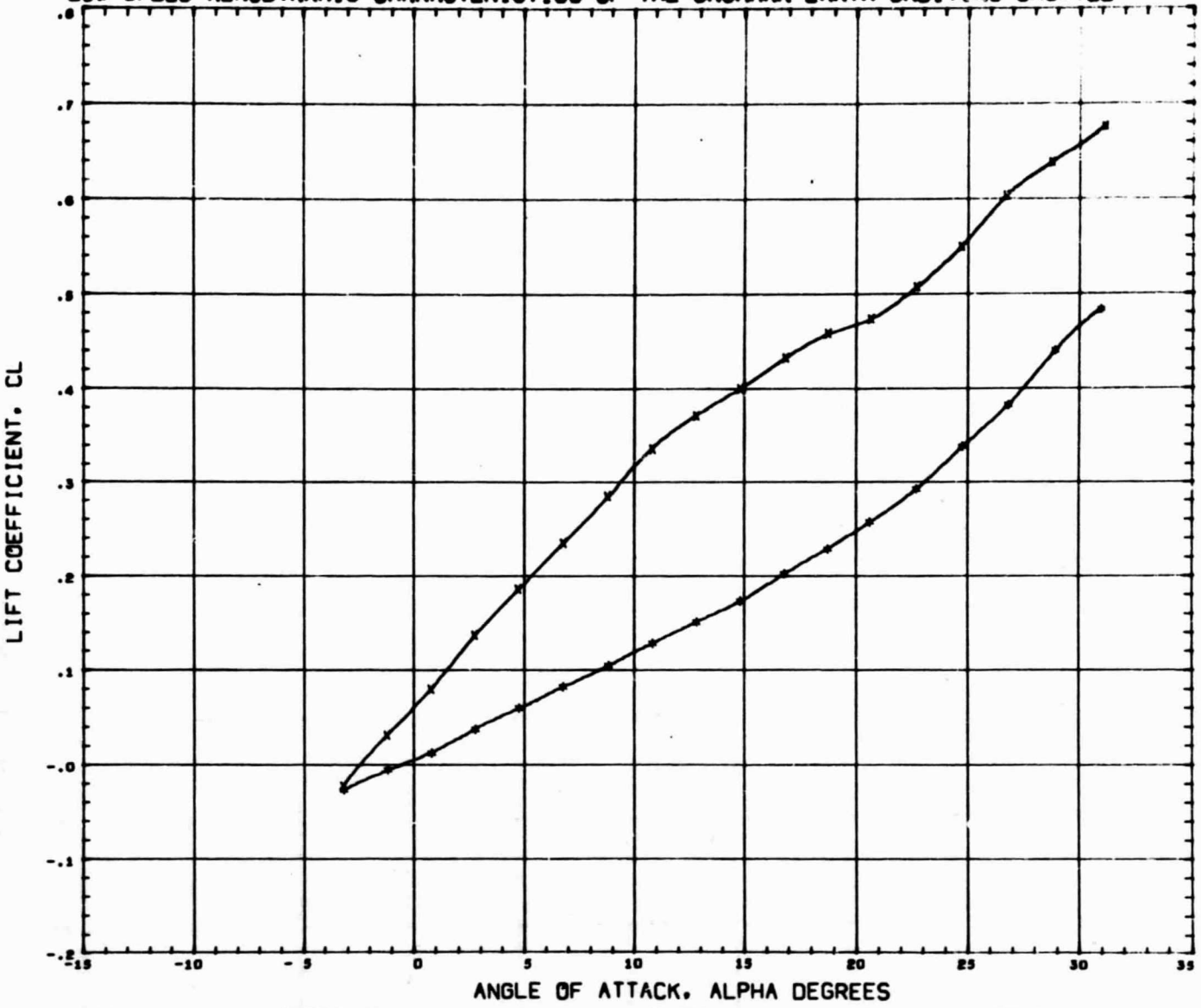
SYMBOL	CONFIGURATION DESCRIPTION	DATA SET	DATE	MACH
*	GWTT28D GAC EARTH ORBITER-B301N301	(AC3101)	13 JUL 70	0.200
X	GWTT28D GAC EARTH ORBITER-B301N301T1,50	(AC3012)	13 JUL 70	

REFERENCE INFORMATION

REFS	3.93750X10^{+00}	SQ.FT.
REFL	3.56250X10^{+00}	FT.
REFB	2.10000X10^{-01}	FT.
XMRF	6.90000X10^{+00}	FT.
YMRF	0.00000X10^{-02}	FT.
ZMRF	8.58000X10^{-02}	FT.
SCALE	2.50000X10	1/40TH

REFERENCE FILE

LOW SPEED AERODYNAMIC CHARACTERISTICS OF THE GRUMMAN EARTH ORBITING SHUTTLE



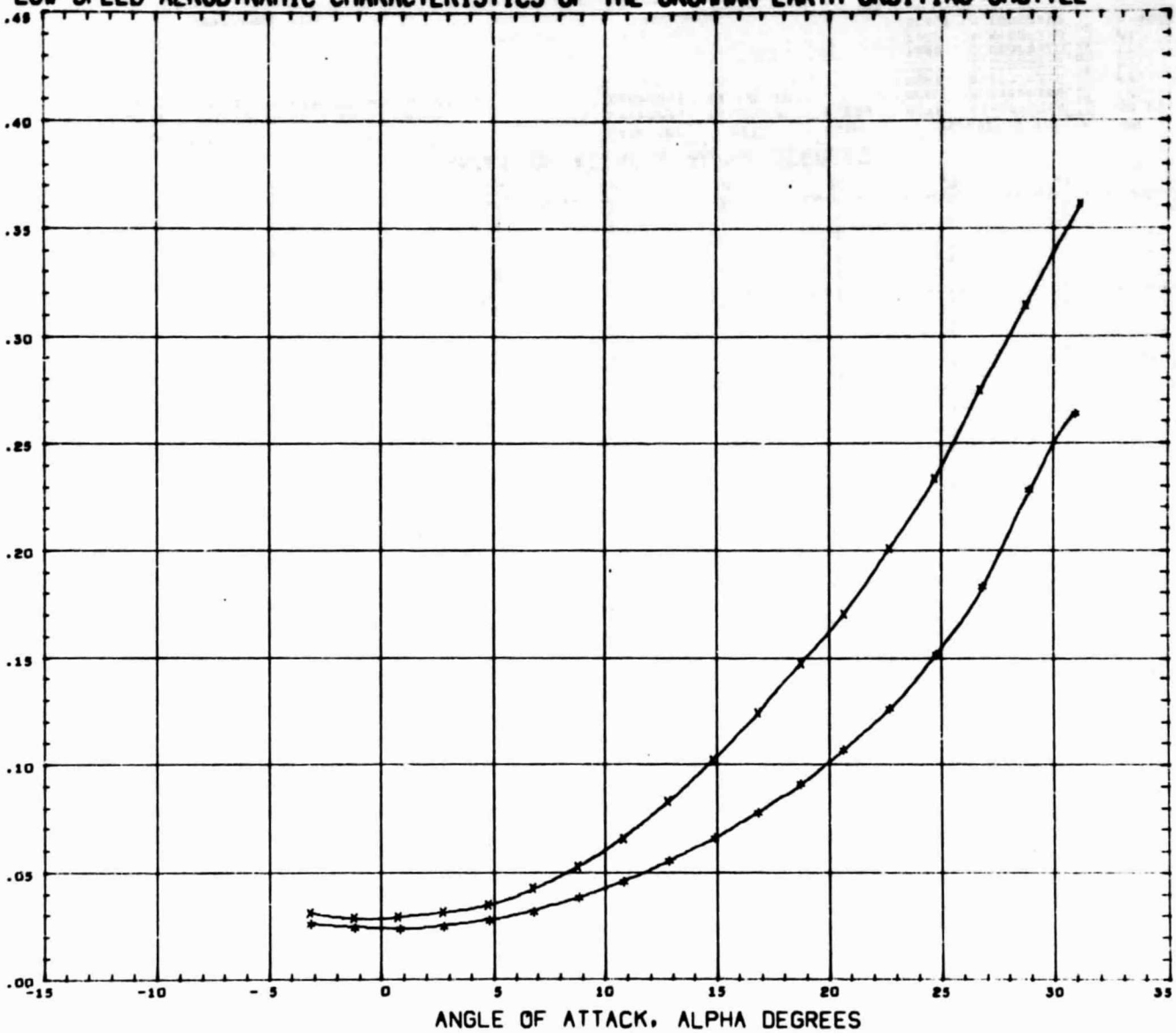
SYMBOL	CONFIGURATION DESCRIPTION	DATA SET	DATE	MACH
*	GWTT280 GAC EARTH ORBITER-B301N301	(RC3062)	13 JUL 70	0.200
X	GWTT280 GAC EARTH ORBITER-B301N301T1,50	(RC3022)	13 JUL 70	

REFERENCE INFORMATION

REFS	$3.93750X10^{+00}$	SQ.FT.
REFL	$3.56250X10^{+00}$	FT.
REFB	$2.10000X10^{-01}$	FT.
XMRP	$6.90000X10^{+00}$	FT.
YMRP	$0.00000X10^{-02}$	FT.
ZMRP	$8.58000X10^{-02}$	FT.
SCALE	$2.50000X10$	1/40TH

REFERENCE FILE

LOW SPEED AERODYNAMIC CHARACTERISTICS OF THE GRUMMAN EARTH ORBITING SHUTTLE



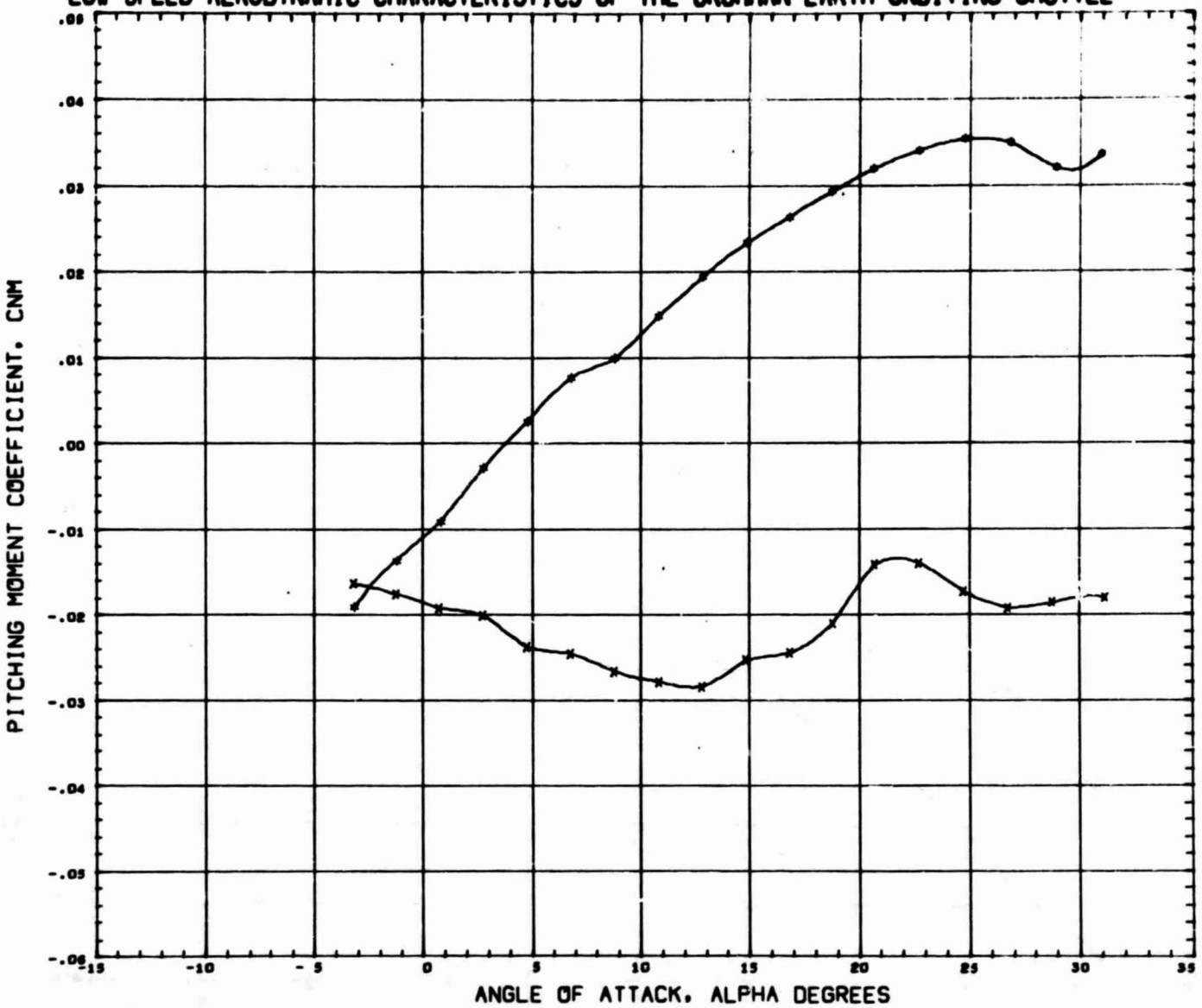
SYMBOL	CONFIGURATION DESCRIPTION	DATA SET	DATE	MACH
*	GWTT28O GAC EARTH ORBITER-B3O1N3O1	(RC3062)	13 JUL 70	0.2CO
X	GWTT28O GAC EARTH ORBITER-B3O1N3O1T1,5O	(RC3022)	13 JUL 70	

REFERENCE INFORMATION

REFS	3.93750X10^{+00}	SQ.FT.
REFL	3.56250X10^{+00}	FT.
REFB	2.10000X10^{-01}	FT.
XMRP	6.90000X10^{+00}	FT.
YMRP	0.00000X10^{-02}	FT.
ZMRP	8.58000X10^{-02}	FT.
SCALE	2.50000X10	1/40TH

REFERENCE FILE

LOW SPEED AERODYNAMIC CHARACTERISTICS OF THE GRUMMAN EARTH ORBITING SHUTTLE

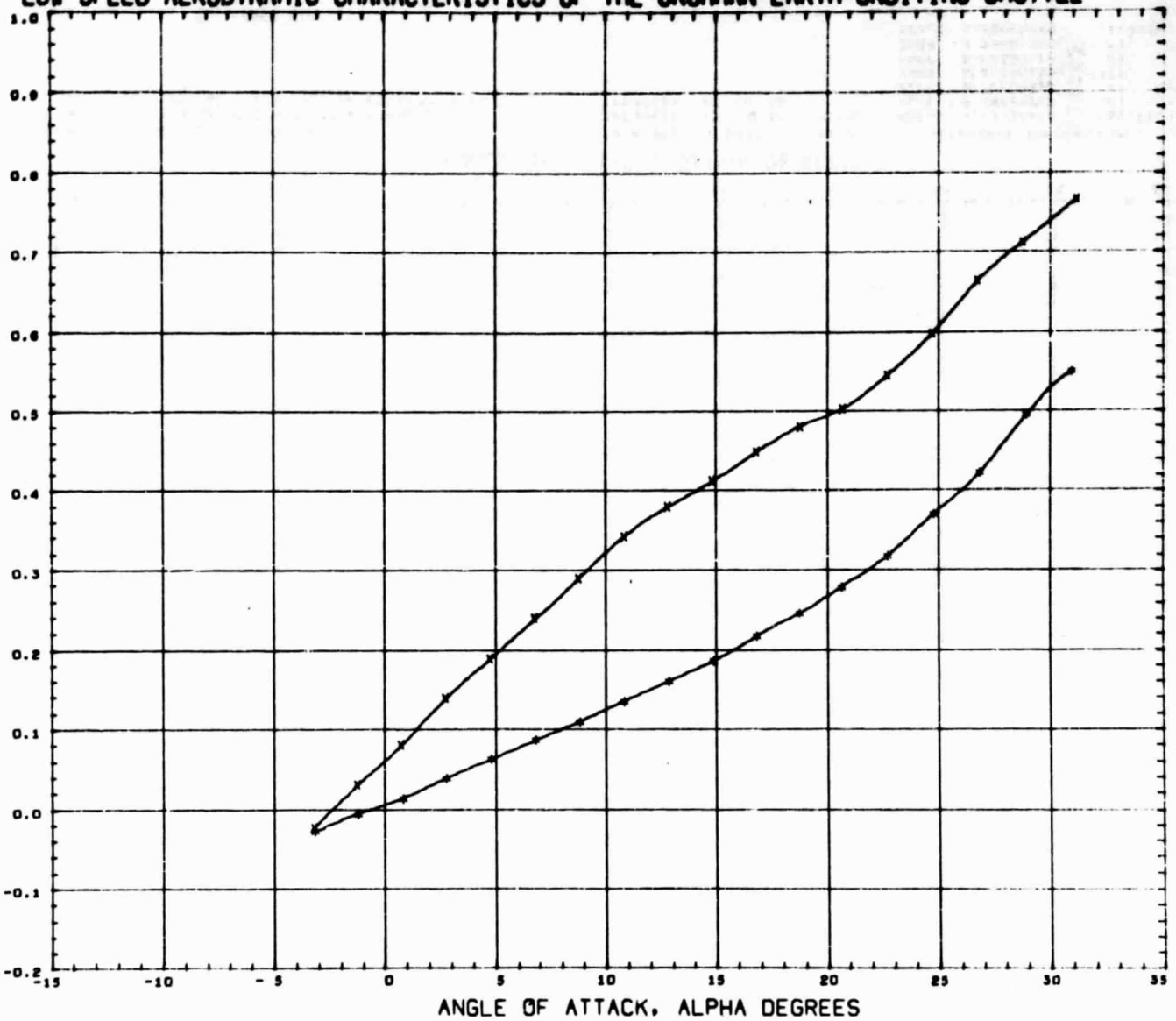


SYMBOL	CONFIGURATION DESCRIPTION	DATA SET	DATE	MACH
*	GWTT280 GAC EARTH ORBITER-B301N301	(RC3062)	13 JUL 70	0.200
X	GWTT280 GAC EARTH ORBITER-B301N301T1,50	(RC3022)	13 JUL 70	

REFERENCE INFORMATION		
REFS	$3.93750X10^{+00}$	SQ.FT.
REFL	$3.56250X10^{+00}$	FT.
REFB	$2.10000X10^{-01}$	FT.
XMRP	$6.90000X10^{+00}$	FT.
YMRP	$0.00000X10^{-02}$	FT.
ZMRP	$8.58000X10^{-02}$	FT.
SCALE	$2.50000X10^{}$	1/40TH

REFERENCE FILE

LOW SPEED AERODYNAMIC CHARACTERISTICS OF THE GRUMMAN EARTH ORBITING SHUTTLE



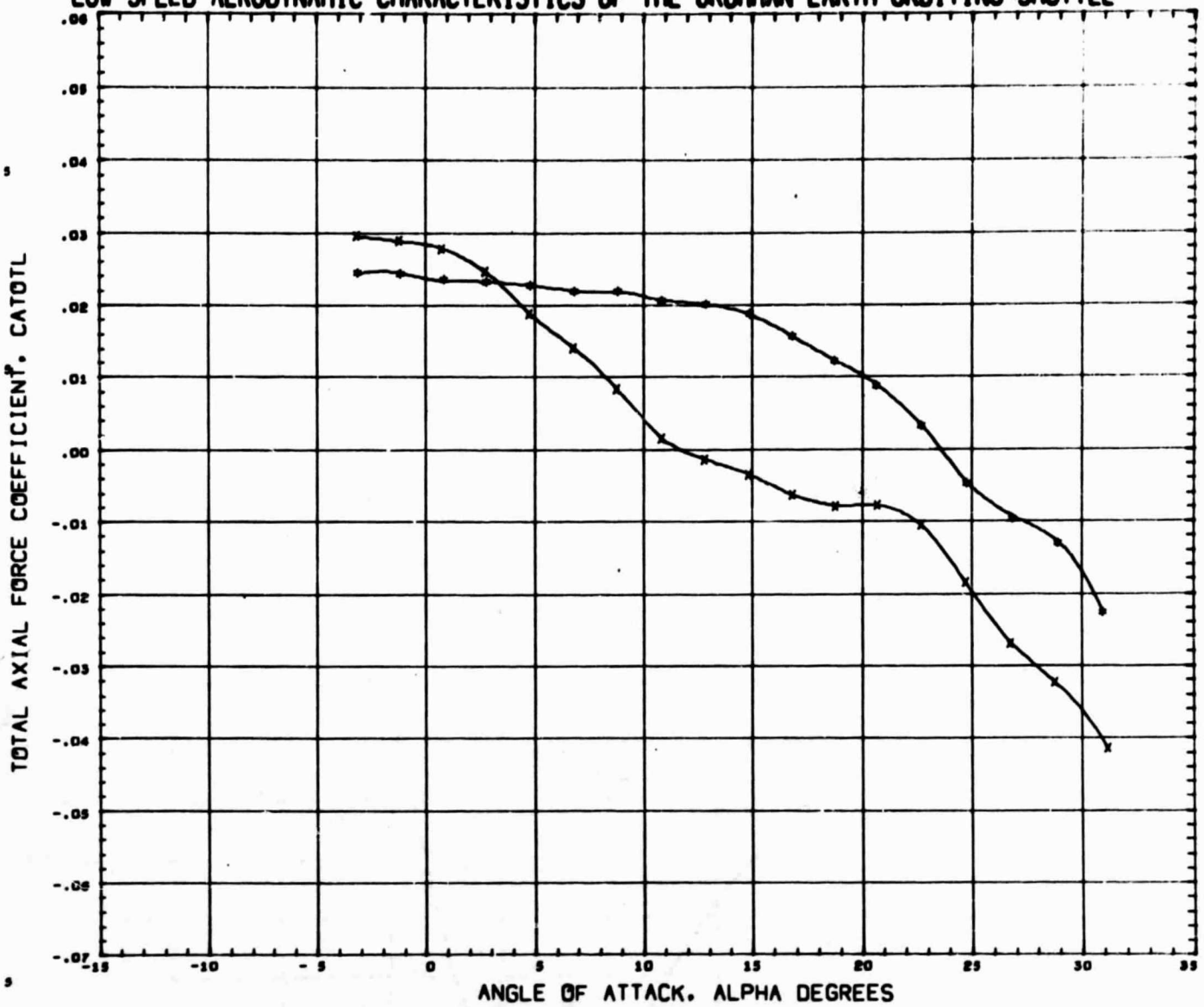
SYMBOL	CONFIGURATION DESCRIPTION	DATA SET	DATE	MACH
*	GWTT280 GAC EARTH ORBITER-B301N301	(BC3062)	13 JUL 70	0.200
X	GWTT280 GAC EARTH ORBITER-B301N301T1,50	(BC3022)	13 JUL 70	

REFERENCE INFORMATION

REFS	3.93750X10^{+00}	SQ.FT.
REFL	3.56250X10^{+00}	FT.
REFB	2.10000X10^{-01}	FT.
XMRP	6.90000X10^{+00}	FT.
YMRP	0.00000X10^{-02}	FT.
ZMRP	8.58000X10^{-02}	FT.
SCALE	2.50000X10	1/40TH

REFERENCE FILE

LOW SPEED AERODYNAMIC CHARACTERISTICS OF THE GRUMMAN EARTH ORBITING SHUTTLE



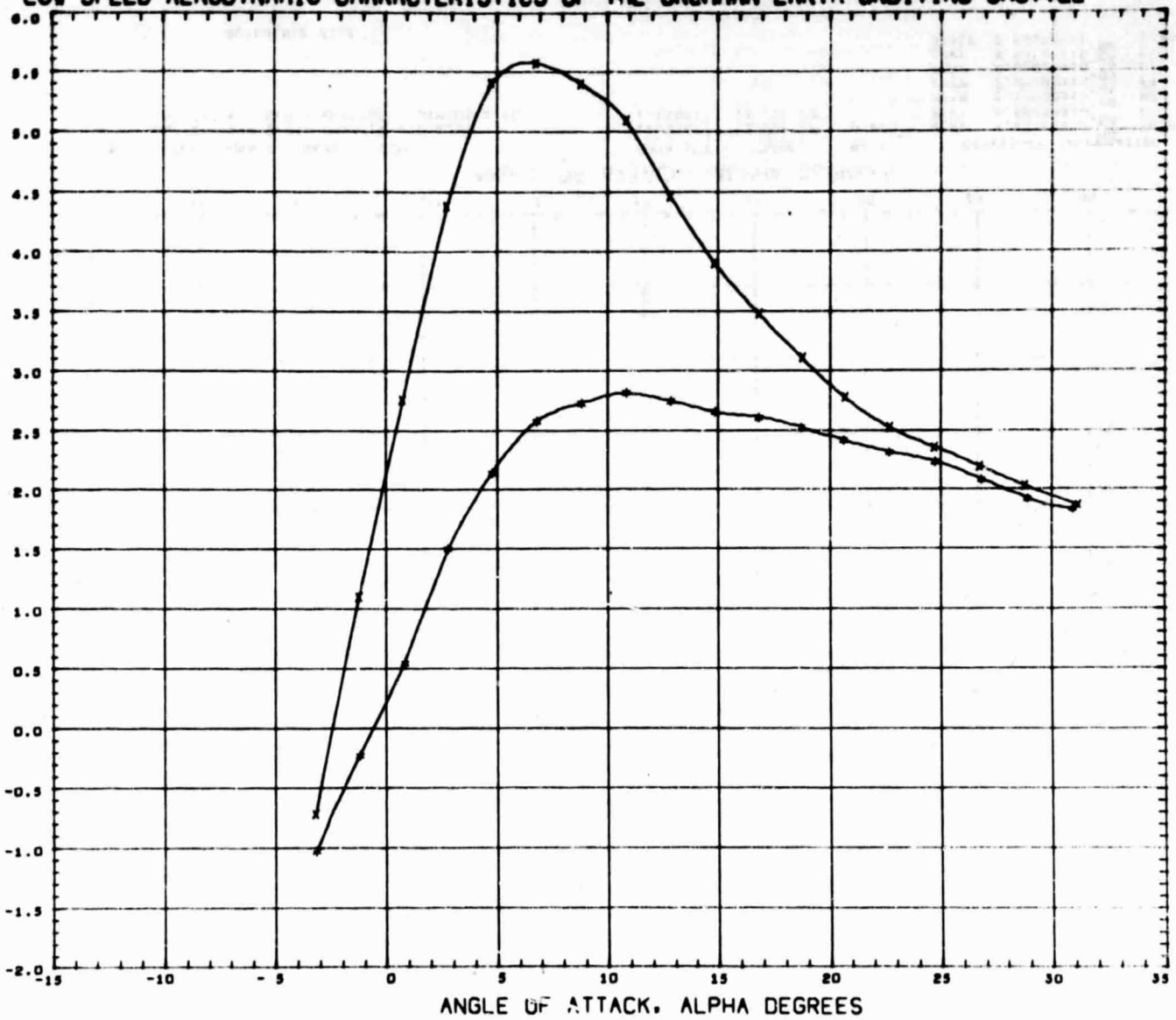
SYMBOL	CONFIGURATION DESCRIPTION	DATA SET	DATE	MACH
*	GWTT280 GAC EARTH ORBITER-B301N301	(BC3062)	13 JUL 70	0.200
X	GWTT280 GAC EARTH ORBITER-B301N301T1,50	(BC3022)	13 JUL 70	

REFERENCE INFORMATION

REFS	3.93750X10^{+00}	SQ.FT.
REFL	3.56250X10^{+00}	FT.
REFB	2.10000X10^{-01}	FT.
XMRP	6.90000X10^{+00}	FT.
YMRP	0.00000X10^{-02}	FT.
ZMRP	8.58000X10^{-02}	FT.
SCALE	2.50000X10	1/40TH

REFERENCE FILE

LOW SPEED AERODYNAMIC CHARACTERISTICS OF THE GRUMMAN EARTH ORBITING SHUTTLE



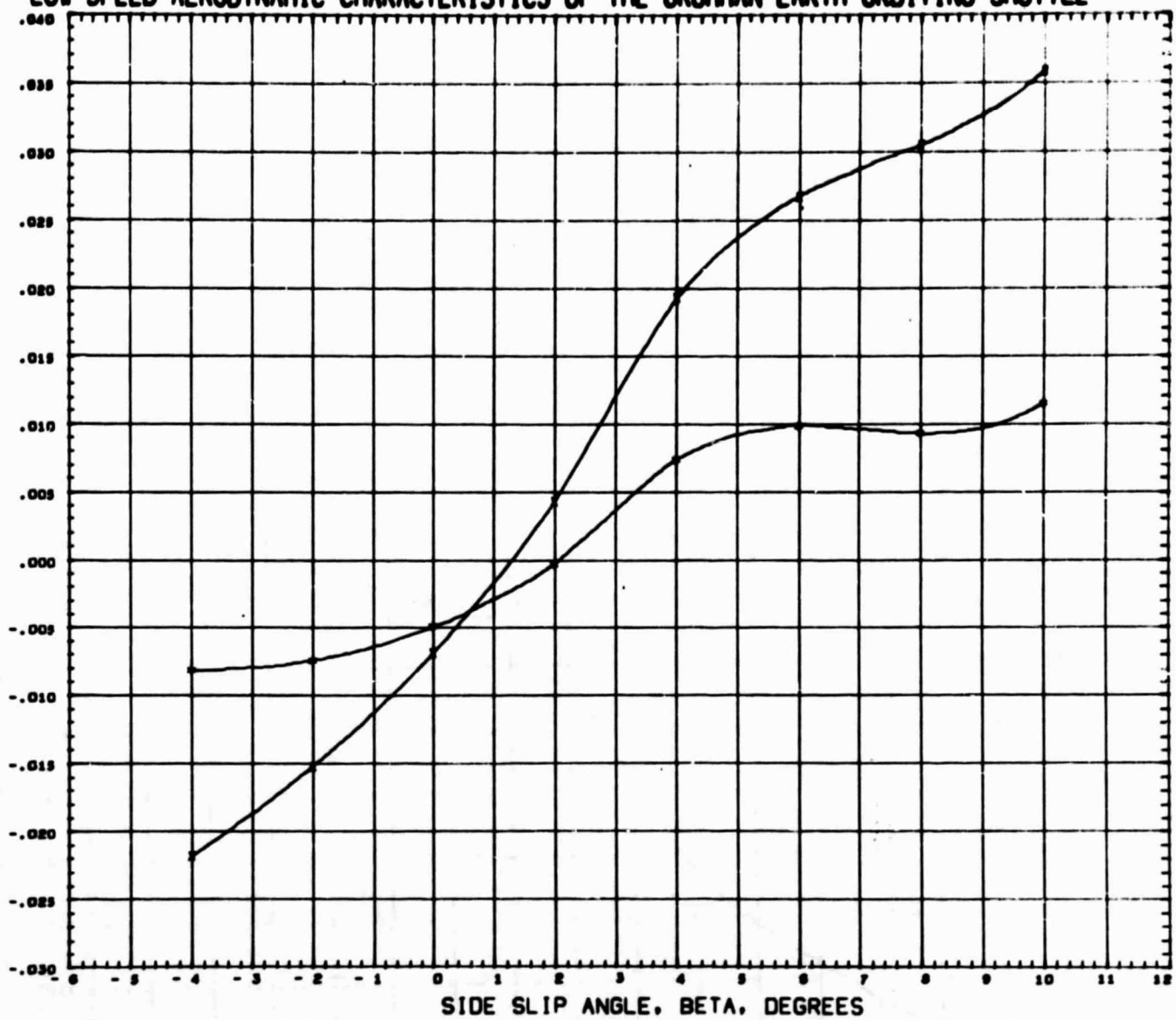
SYMBOL	CONFIGURATION DESCRIPTION	DATA SET	DATE	MACH
*	GWTT280 GAC EARTH ORBITER-B301N301	(AC3062)	13 JUL 70	0.200
X	GWTT280 GAC EARTH ORBITER-B301N301T1,50	(AC3022)	13 JUL 70	

REFERENCE INFORMATION

REFS	3.93750X10^{+00}	SQ.FT.
REFL	3.56250X10^{+00}	FT.
REFB	2.10000X10^{-01}	FT.
XMRP	6.90000X10^{+00}	FT.
YMRP	0.00000X10^{-02}	FT.
ZMRP	8.58000X10^{-02}	FT.
SCALE	2.50000X10	1/40TH

REFFRENCE FILE

LOW SPEED AERODYNAMIC CHARACTERISTICS OF THE GRUMMAN EARTH ORBITING SHUTTLE



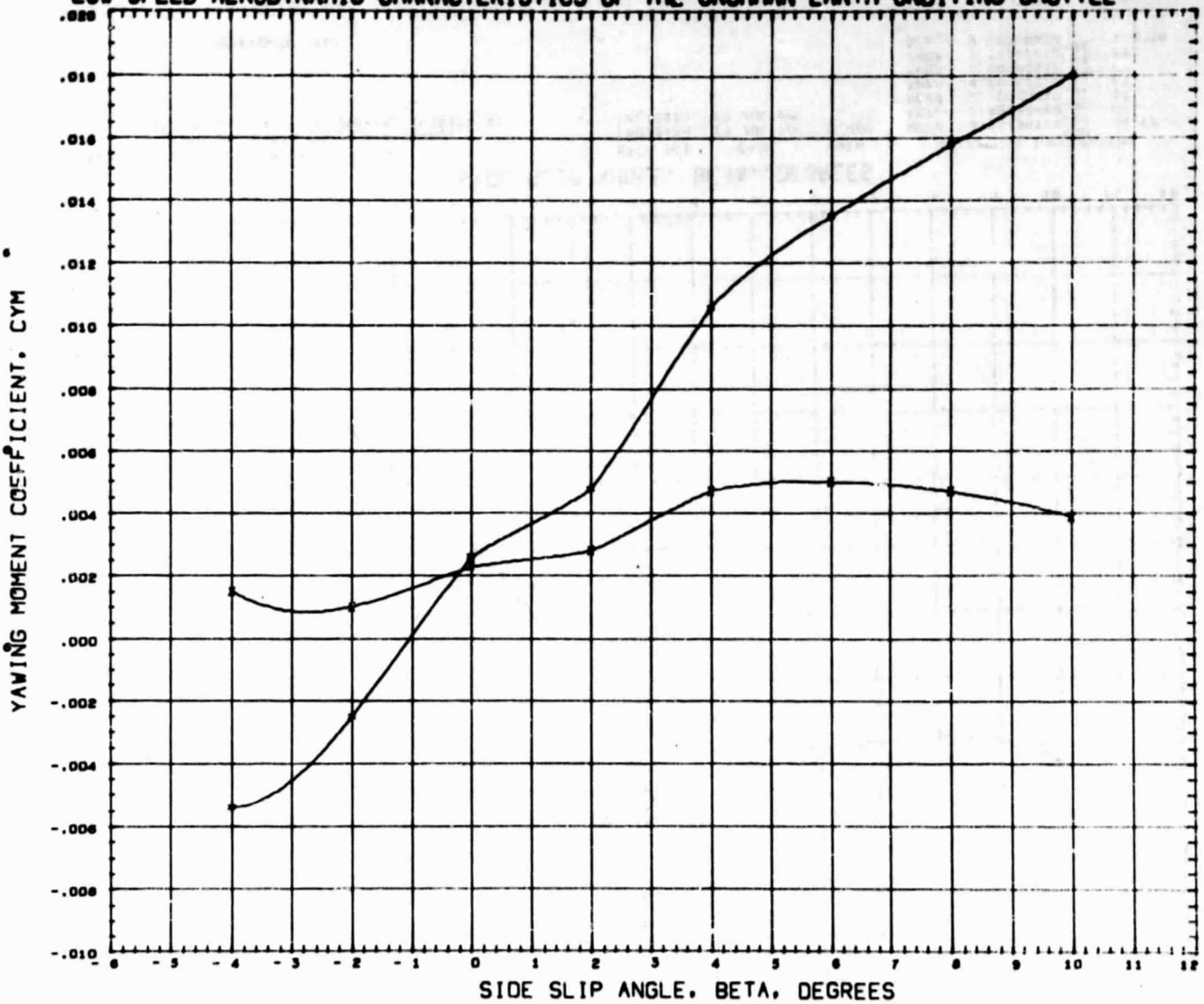
SYMBOL	CONFIGURATION DESCRIPTION	DATA SET	DATE	MACH
*	GWTT280 GAC EARTH ORBITER-B301N301	(RC3097)	13 JUL 70	0.200
X	GWTT280 GAC EARTH ORBITER-B301N301T1,50	(RC3037)	13 JUL 70	

REFERENCE INFORMATION

REFS	$3.93750X10^{+00}$	SQ.FT.
REFL	$3.56250X10^{+00}$	FT.
REFB	$2.10000X10^{-01}$	FT.
XMRP	$6.90000X10^{+00}$	FT.
YMRP	$0.00000X10^{-02}$	FT.
ZMRP	$8.58000X10^{-02}$	FT.
SCALE	$2.50000X10^{}$	1/40TH

REFERENCE FILE

LOW SPEED AERODYNAMIC CHARACTERISTICS OF THE GRUMMAN EARTH ORBITING SHUTTLE



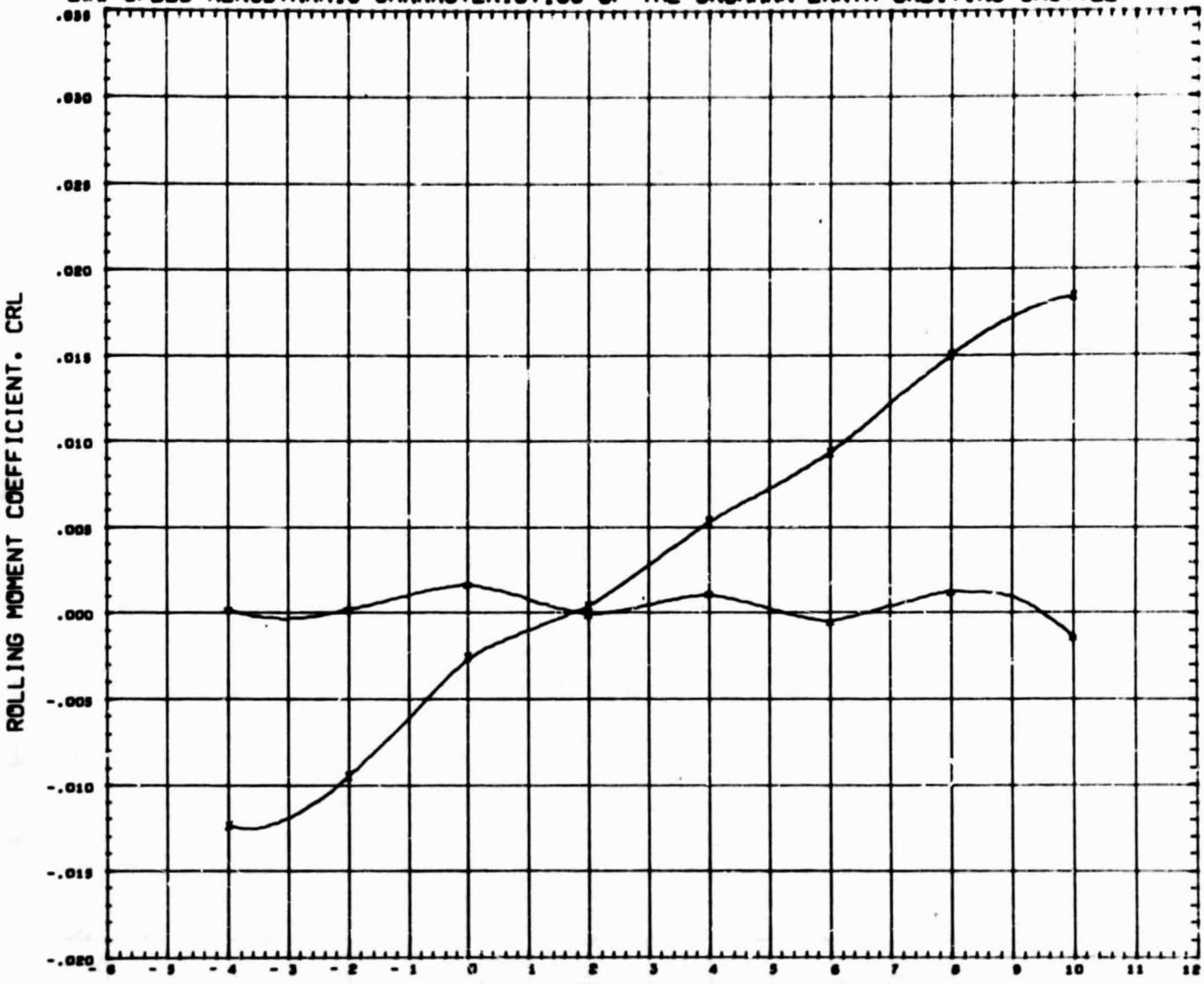
SYMBOL	CONFIGURATION DESCRIPTION	DATA SET	DATE	MACH
*	GWTT280 GAC EARTH ORBITER-B301N301	(RC3097)	13 JUL 70	0.200
X	GWTT280 GAC EARTH ORBITER-B301N301T1,50	(RC3037)	13 JUL 70	

REFERENCE INFORMATION

REFS	3.93750X10^{+00}	SQ.FT.
REFL	3.96250X10^{+00}	FT.
REFB	2.10000X10^{+00}	FT.
XMRP	6.90000X10^{-01}	FT.
YMRP	0.00000X10^{+00}	FT.
ZMRP	8.50000X10^{-02}	FT.
SCALE	2.50000X10^{-02}	1/40TH

REFERENCE FILE

LOW SPEED AERODYNAMIC CHARACTERISTICS OF THE GRUMMAN EARTH ORBITING SHUTTLE



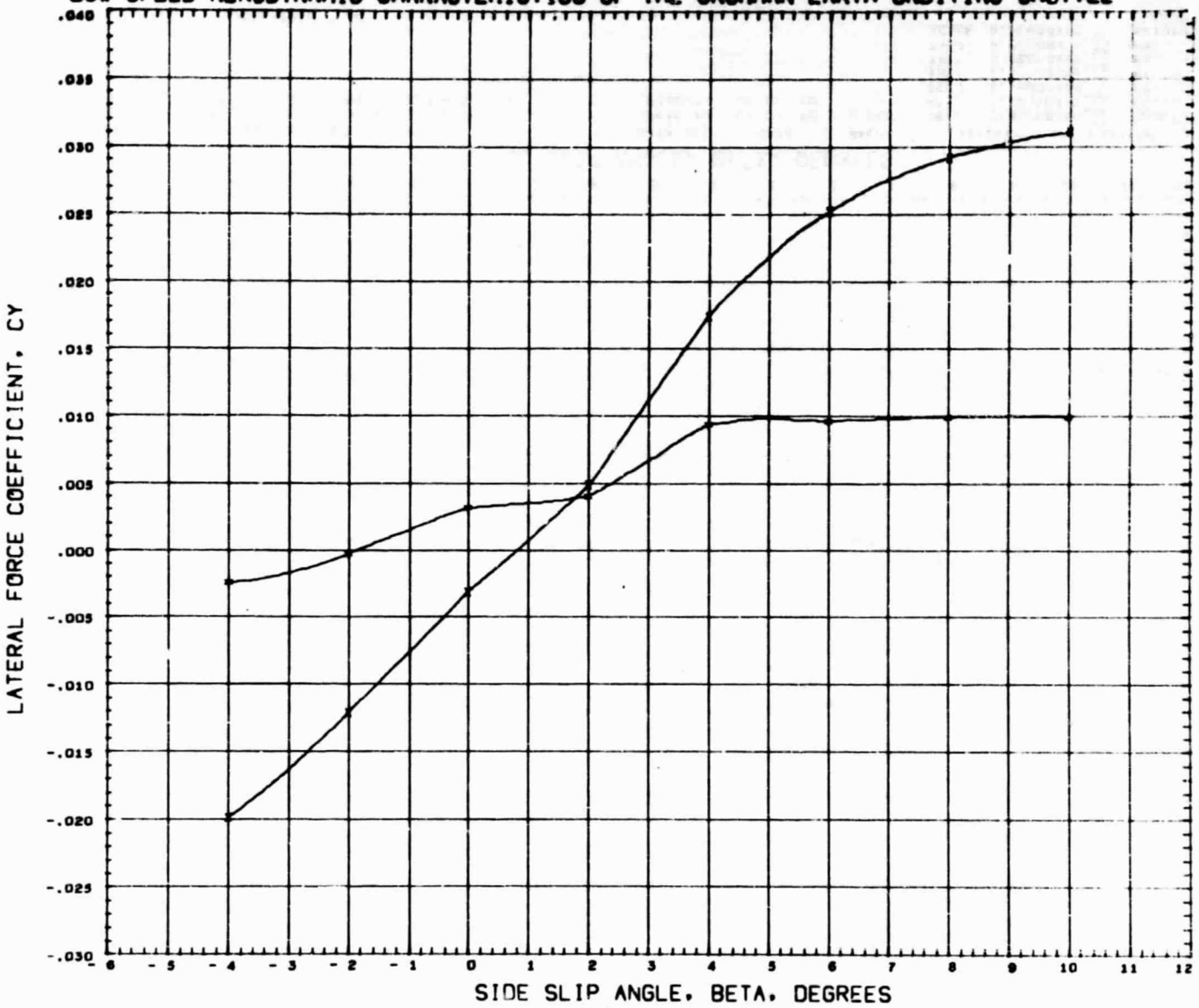
SYMBOL	CONFIGURATION DESCRIPTION	DATA SET	DATE	MACH
⊕	GWTT280 GAC EARTH ORBITER-B301N301	(RC3097)	13 JUL 70	0.200
X	GWTT280 GAC EARTH ORBITER-B301N301T1,50	(RC3037)	13 JUL 70	

REFERENCE INFORMATION

REFS	3.93750X10+00	SQ.FT.
REFL	3.56250X10+00	FT.
REFB	2.10000X10-01	FT.
XMRP	6.93000X10+00	FT.
YMRP	0.00000X10-02	FT.
ZMRP	8.58000X10-02	FT.
SCALE	2.50000X10	1/40TH

REFERENCE FILE

LOW SPEED AERODYNAMIC CHARACTERISTICS OF THE GRUMMAN EARTH ORBITING SHUTTLE

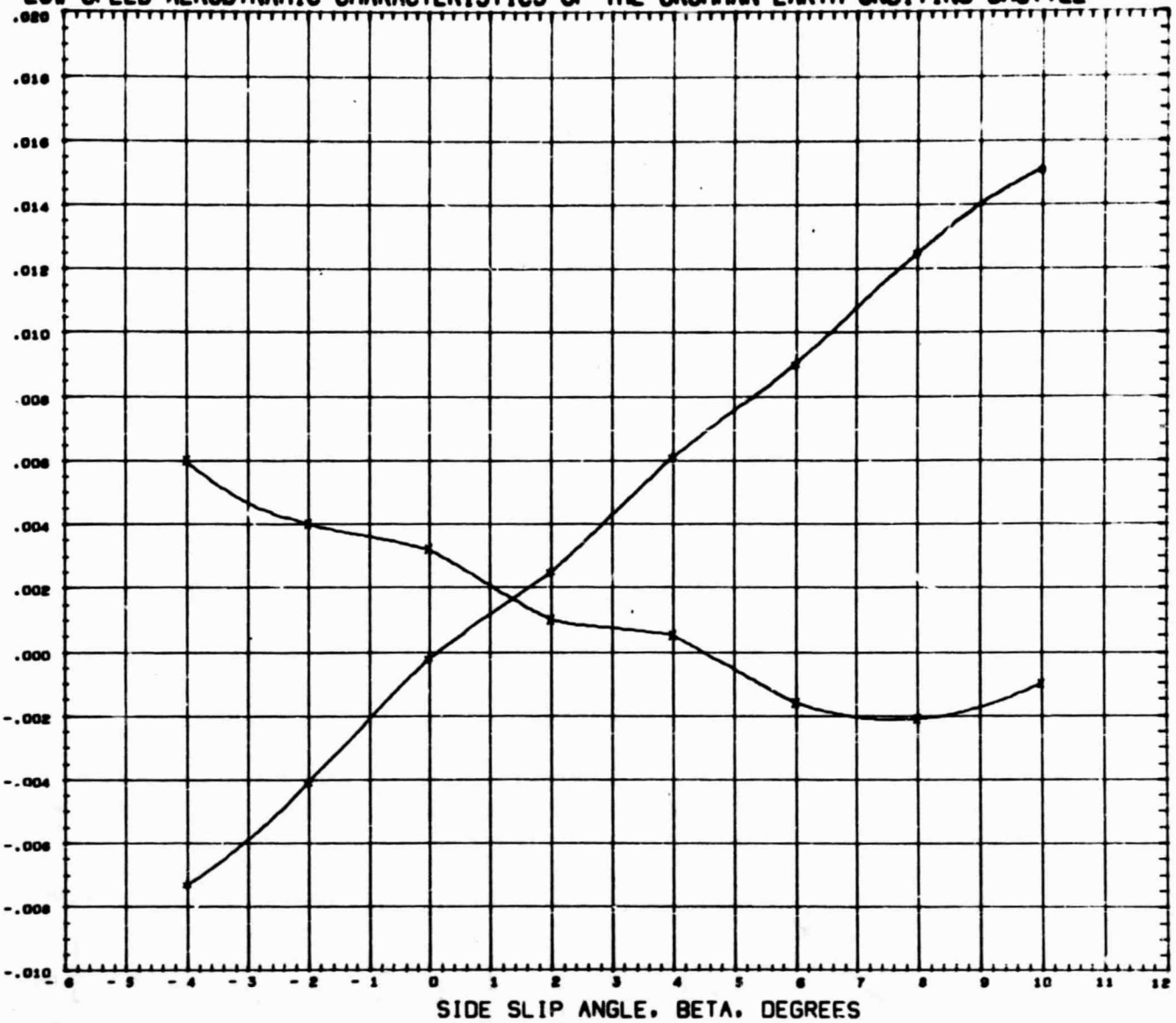


SYMBOL	CONFIGURATION DESCRIPTION	DATA SET	DATE	MACH
*	GWTT280 GAC EARTH ORBITER-B301N301	(RC3087)	13 JUL 70	0.200
X	GWTT280 GAC EARTH ORBITER-B301N301T1,50	(RC3047)	13 JUL 70	

REFERENCE FILE

REFERENCE INFORMATION		
REFS	$3.93750X10^{+00}$	SQ.FT.
REFL	$3.56250X10^{+00}$	FT.
REFB	$2.10000X10^{-01}$	FT.
XMRP	$6.90000X10^{+00}$	FT.
YMRP	$0.00000X10^{-02}$	FT.
ZMRP	$8.58000X10^{-02}$	FT.
SCALE	$2.50000X10^{}$	1/40TH

LOW SPEED AERODYNAMIC CHARACTERISTICS OF THE GRUMMAN EARTH ORBITING SHUTTLE



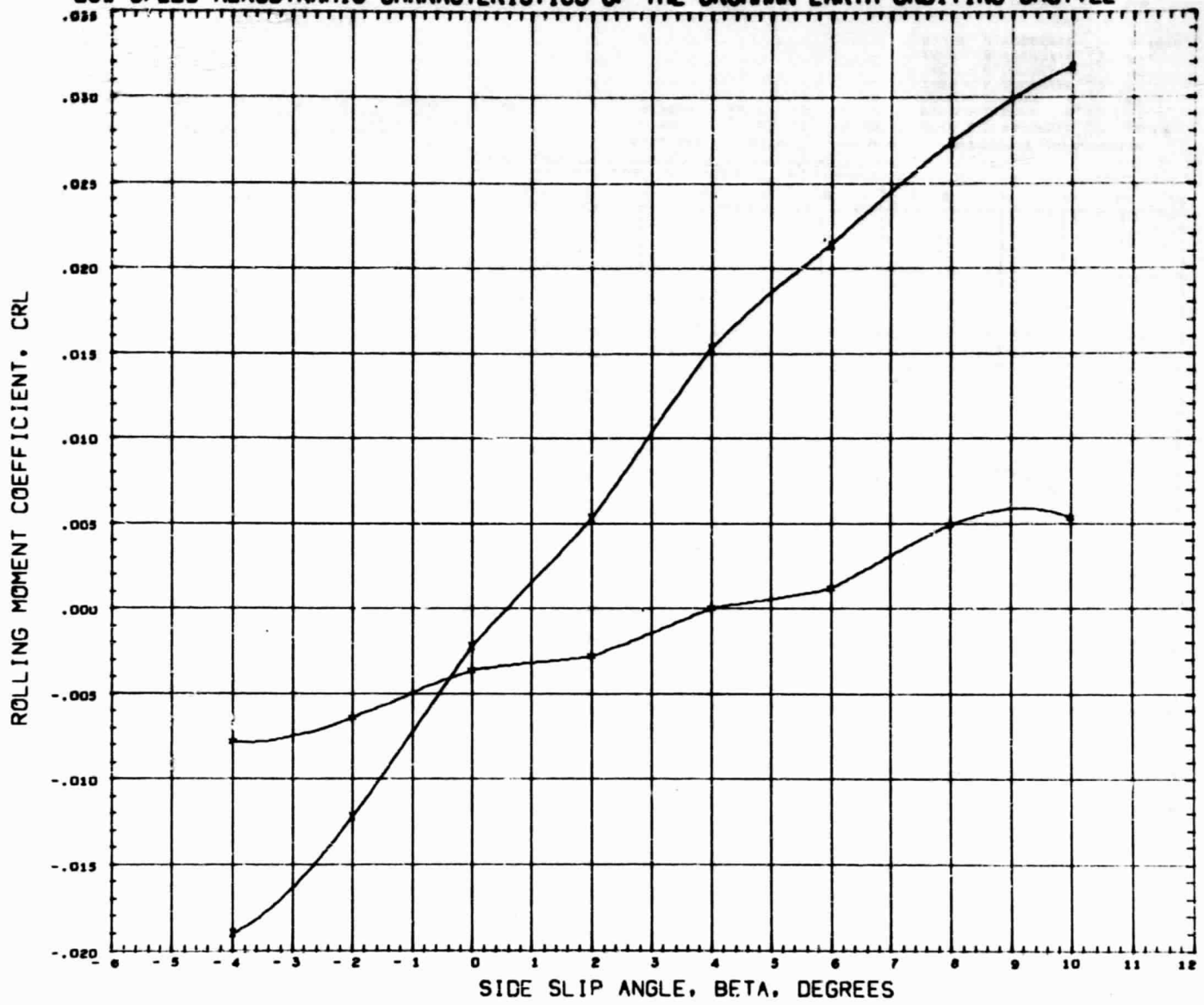
SYMBOL	CONFIGURATION DESCRIPTION	DATA SET	DATE	MACH
*	GWTT280 GAC EARTH ORBITER-B301N301	(RC3067)	13 JUL 70	0.200
X	GWTT280 GAC EARTH ORBITER-B301N301T1,50	(RC3047)	13 JUL 70	

REFERENCE INFORMATION

REFS	$3.93750 \times 10^{+00}$	SQ.FT.
REFL	$3.56250 \times 10^{+00}$	FT.
REFB	2.10000×10^{-01}	FT.
XMRP	$6.90000 \times 10^{+00}$	FT.
YMRP	$0.00000 \times 10^{+00}$	FT.
ZMRP	8.58000×10^{-02}	FT.
SCALE	2.50000×10^{0}	1/40TH

REFERENCE FILE

LOW SPEED AERODYNAMIC CHARACTERISTICS OF THE GRUMMAN EARTH ORBITING SHUTTLE



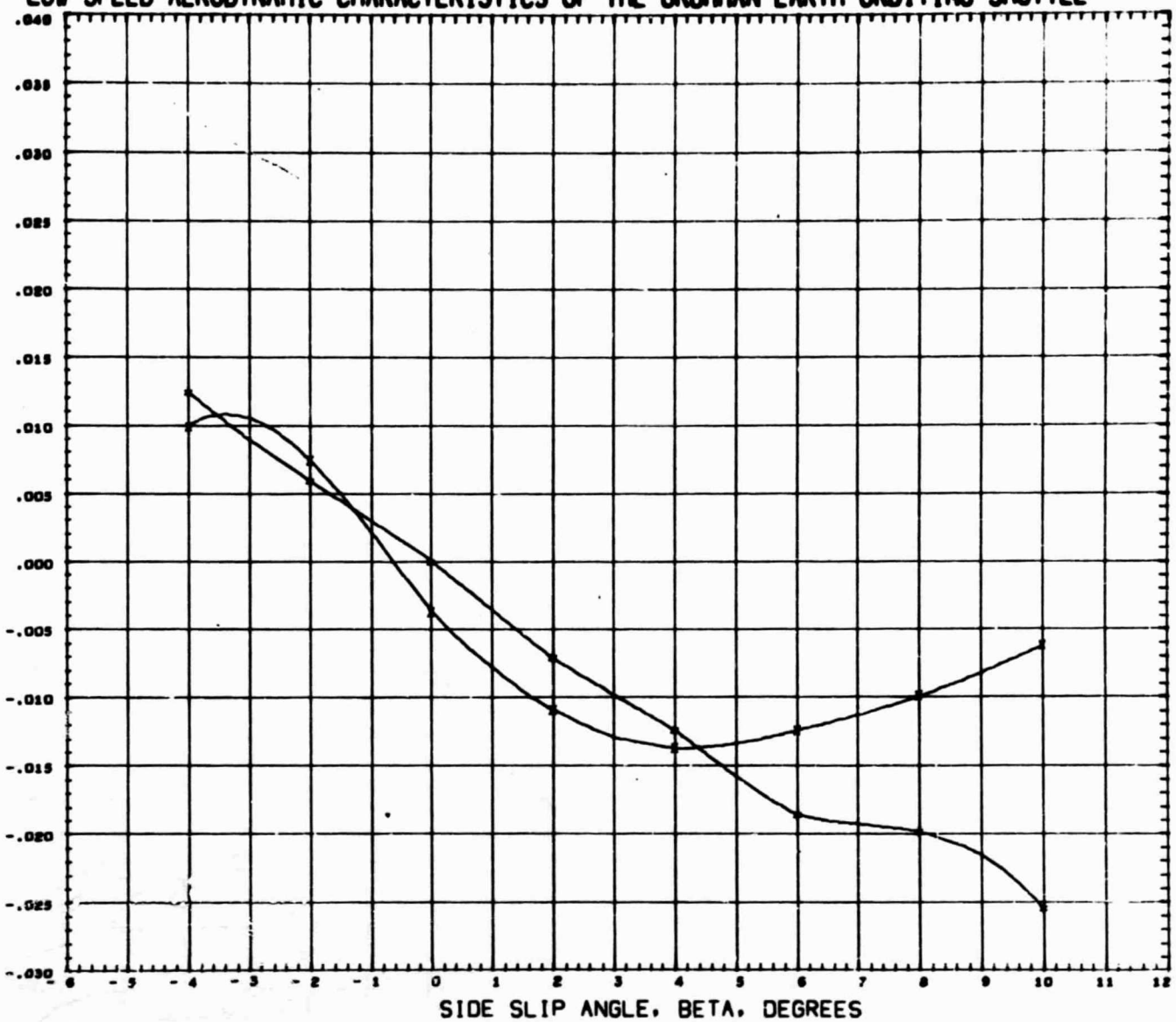
SYMBOL	CONFIGURATION DESCRIPTION	DATA SET	DATE	MACH
*	GWTT280 GAC EARTH ORBITER-B301N301	(RC3087)	13 JUL 70	0.200
X	GWTT280 GAC EARTH ORBITER-B301N301T1,5G	(RC3047)	13 JUL 70	

REFERENCE INFORMATION

REFS	3.93750X10^{+00}	SQ.FT.
REFL	3.56250X10^{+00}	FT.
REFB	2.10000X10^{-01}	FT.
XMRP	6.90000X10^{+00}	FT.
YMRP	0.00000X10^{-02}	FT.
ZMRP	8.58000X10^{-02}	FT.
SCALE	2.50000X10	1/40TH

REFERENCE FILE

LOW SPEED AERODYNAMIC CHARACTERISTICS OF THE GRUMMAN EARTH ORBITING SHUTTLE



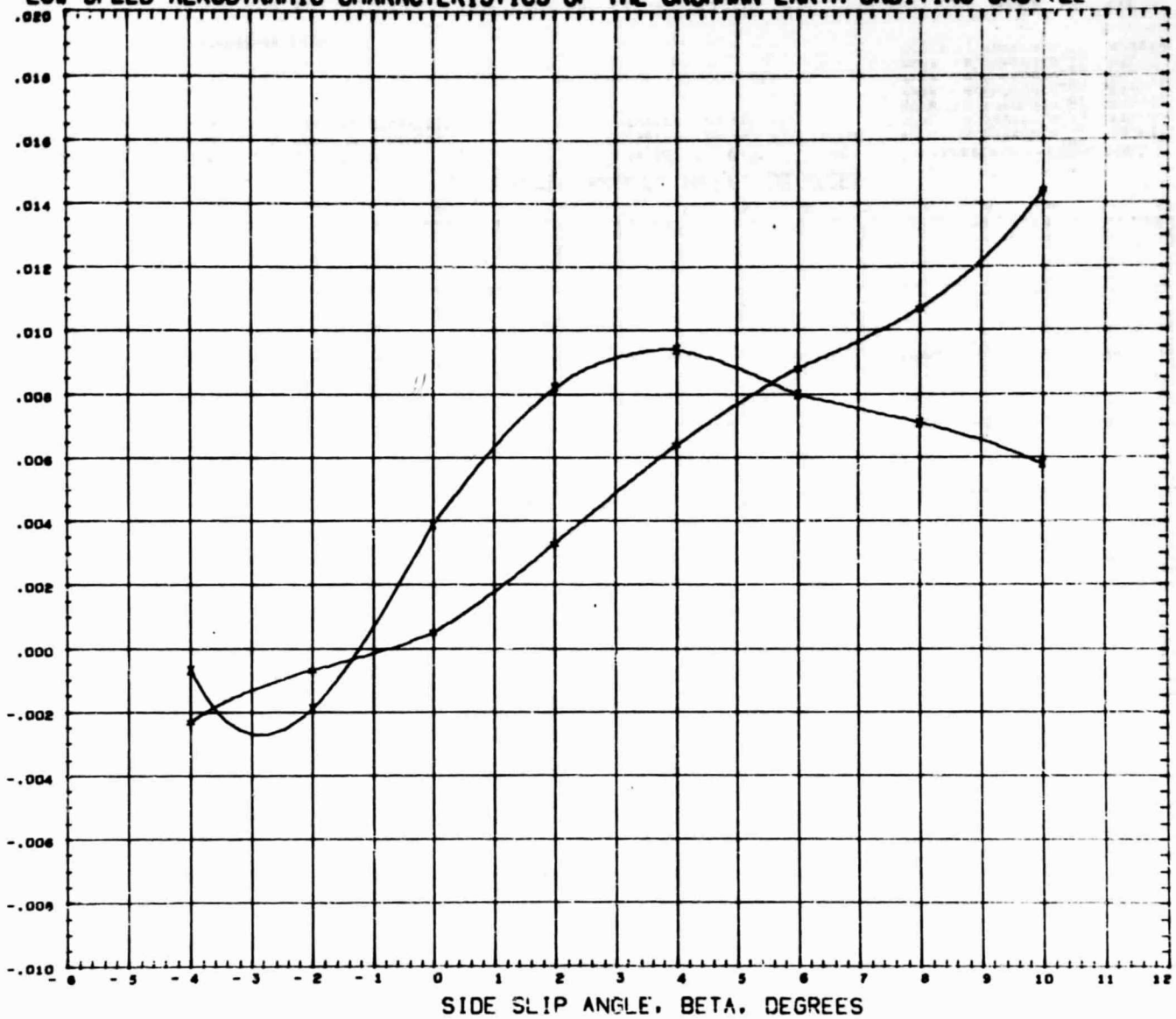
SYMBOL	CONFIGURATION DESCRIPTION	DATA SET	DATE	MACH
*	GWTT28D GAC EARTH ORBITER-B301N301	(RC3077)	13 JUL 70	0.200
X	GWTT28D GAC EARTH ORBITER-B301N301T1,50	(RC3057)	13 JUL 70	

REFERENCE INFORMATION

REFS	3.93750X10^{+00}	SQ.FT.
REFL	3.56250X10^{+00}	FT
REFB	2.10000X10^{-01}	FT.
XMRP	6.90000X10^{+00}	FT.
YMRP	0.00000X10^{-02}	FT.
ZMRP	8.58000X10^{-02}	FT.
SCALE	2.50000X10	1/4C1H

REFERENCE FILE

LOW SPEED AERODYNAMIC CHARACTERISTICS OF THE GRUMMAN EARTH ORBITING SHUTTLE



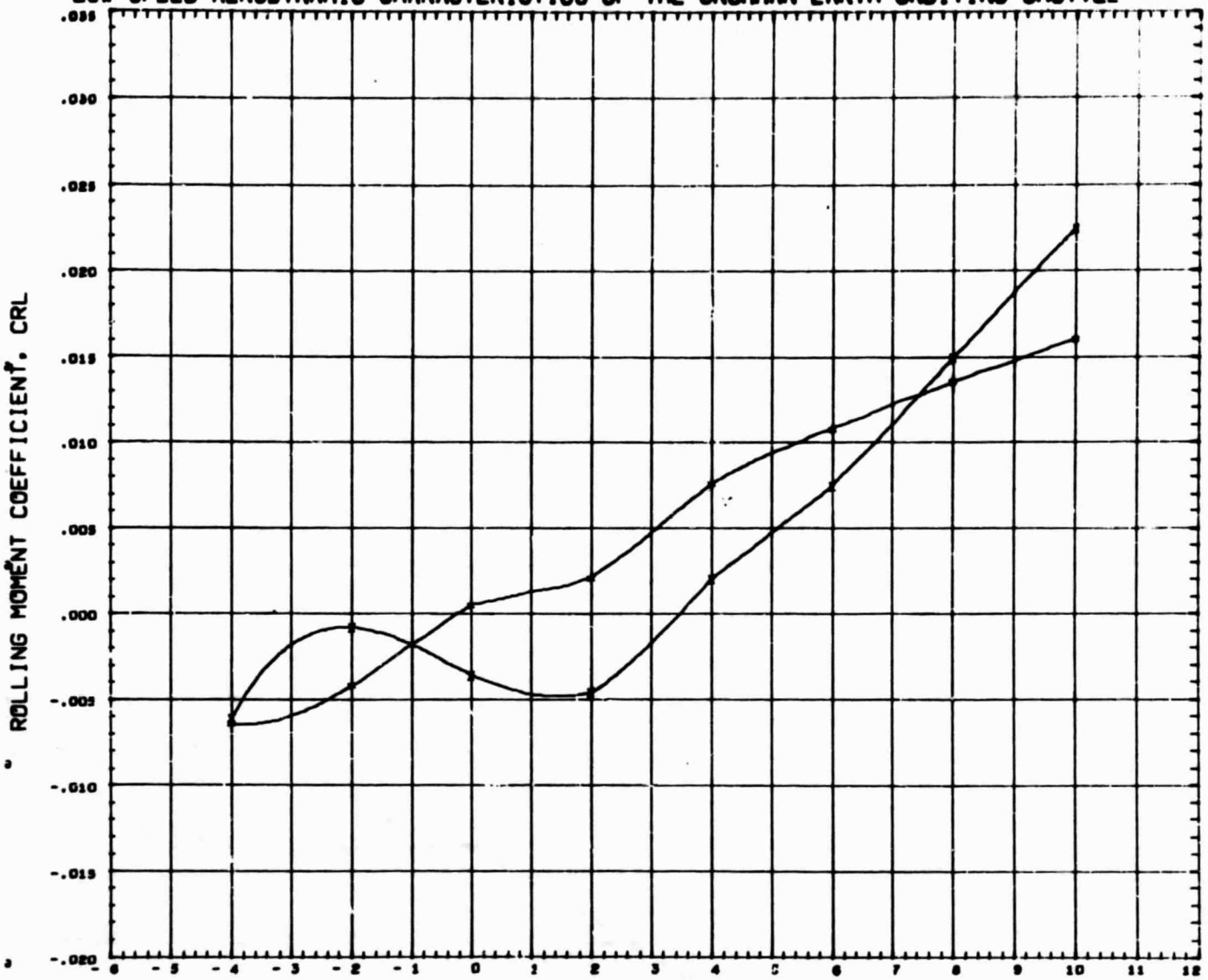
SYMBOL	CONFIGURATION DESCRIPTION	DATA SET	DATE	MACH
*	GWTT280 GAC EARTH ORBITER-B301N301	(RC3077)	13 JUL 70	0.200
X	GWTT280 GAC EARTH ORBITER-B301N301T1,50	(RC3057)	13 JUL 70	

REFERENCE INFORMATION

REFS	$3.93750 \times 10^{+00}$	SQ.FT.
REFL	$3.56250 \times 10^{+00}$	FT.
REFB	2.10000×10^{-01}	FT.
XMRP	$6.90000 \times 10^{+00}$	FT.
YMRP	0.00000×10^{-02}	FT.
ZMRP	8.58000×10^{-02}	FT.
SCALE	$2.50000 \times 10^{}$	1/40TH

REFERENCE FILE

LOW SPEED AERODYNAMIC CHARACTERISTICS OF THE GRUMMAN EARTH ORBITING SHUTTLE



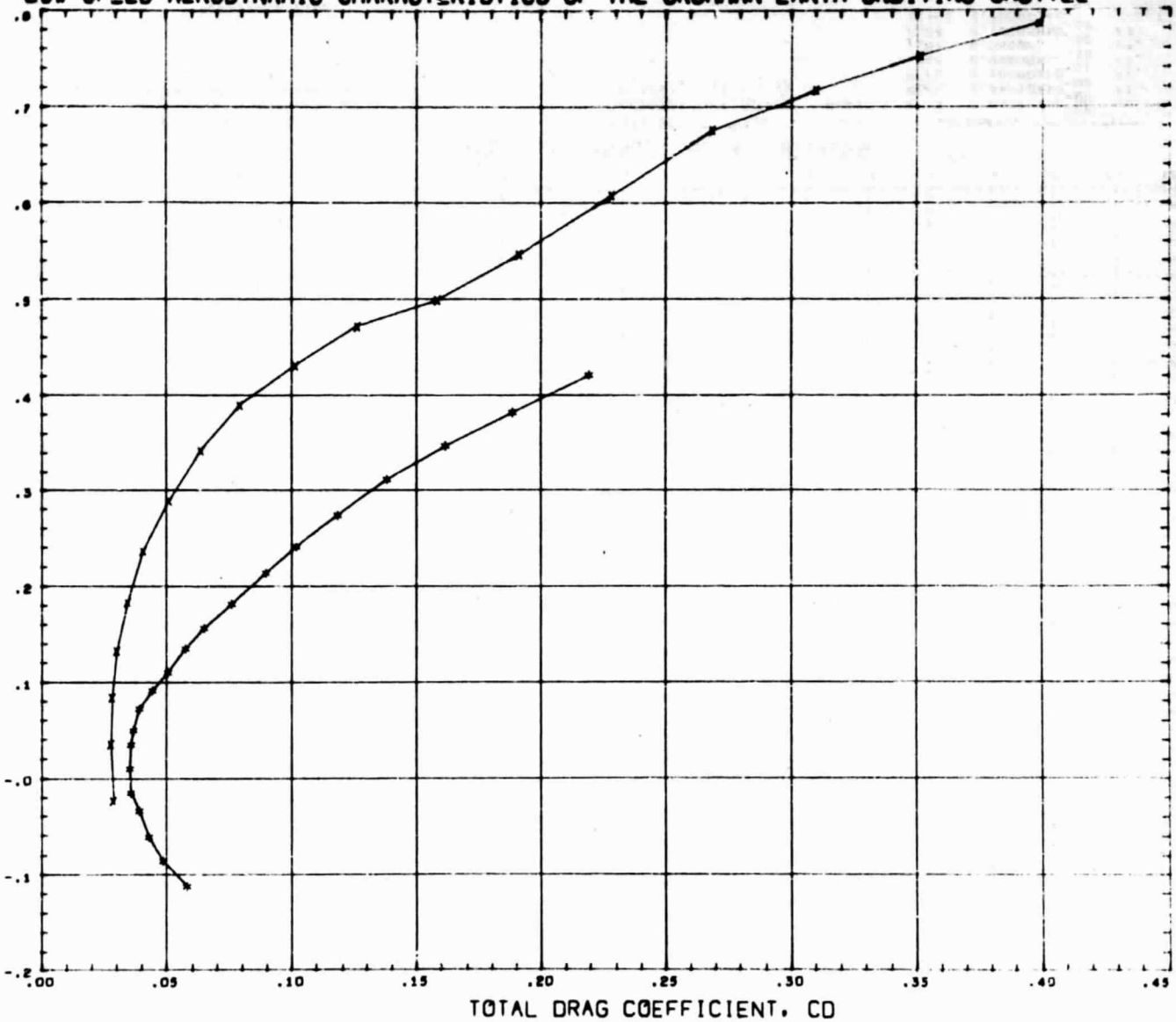
SYMBOL	CONFIGURATION DESCRIPTION	DATA SET	DATE	MACH
*	GWTT280 GAC EARTH ORBITER-B301N301	(RC3077)	13 JUL 70	0.200
X	GWTT280 GAC EARTH ORBITER-B301N301T1,50	(RC3057)	13 JUL 70	

REFERENCE INFORMATION

REFS	3.93750X10^{+00}	30.FT.
REFL	3.56250X10^{+00}	FT.
REFB	2.10000X10^{-01}	FT.
XMRP	6.90000X10^{+00}	FT.
YMRP	0.00000X10^{-02}	FT.
ZMRP	8.58000X10^{-02}	FT.
SCALE	2.50000X10^{-}	1/40TH

REFERENCE FILE

LOW SPEED AERODYNAMIC CHARACTERISTICS OF THE GRUMMAN EARTH ORBITING SHUTTLE



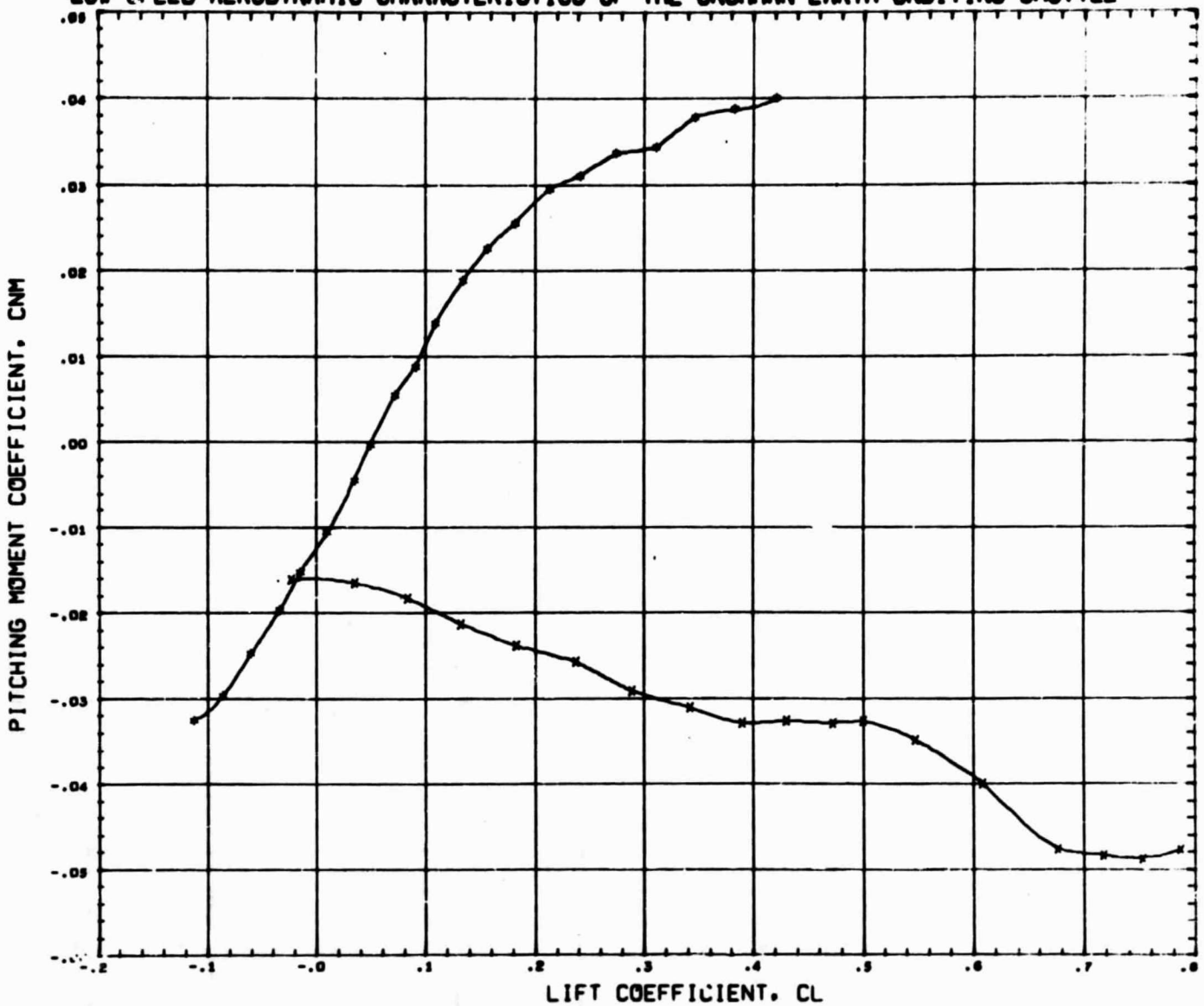
SYMBOL	CONFIGURATION DESCRIPTION	DATA SET	DATE	MACH
*	GWTT280 GAC EARTH ORBITER-B301N301	(RC3101)	13 JUL 70	0.200
x	GWTT280 GAC EARTH ORBITER-B301N301T1,50	(RC3012)	13 JUL 70	

REFERENCE INFORMATION

REFS	3.93750X10^{+00}	SQ.FT.
REFL	3.56250X10^{+00}	FT.
REFB	2.10000X10^{-01}	FT.
XMRF	6.90000X10^{+00}	FT.
YMRF	0.00000X10^{-02}	FT.
ZMRF	8.58000X10^{-02}	FT.
SCALE	2.50000X10	1/40TH

REFERENCE FILE

LOW SPEED AERODYNAMIC CHARACTERISTICS OF THE GRUMMAN EARTH ORBITING SHUTTLE



SYMBOL	CONFIGURATION DESCRIPTION	DATA SET	DATE	MACH
⊕	GWTT280 GAC EARTH ORBITER-B301N3D1	(RC3101)	13 JUL 70	0.200
X	GWTT280 GAC EARTH ORBITER-B301N301T1,90	(RC3012)	13 JUL 70	

REFERENCE INFORMATION

REFS	$3.93750 \times 10^{+00}$	SQ.FT.
REFL	$3.56250 \times 10^{+00}$	FT.
REFB	2.10000×10^{-01}	FT.
XMRP	$6.90000 \times 10^{+00}$	FT.
YMRP	0.00000×10^{-02}	FT.
ZMRP	8.58000×10^{-02}	FT.
SCALE	2.50000×10^{-02}	1/40TH

REFERENCE FILE

LOW SPEED AERODYNAMIC CHARACTERISTICS OF THE GRUMMAN EARTH ORBITING SHUTTLE

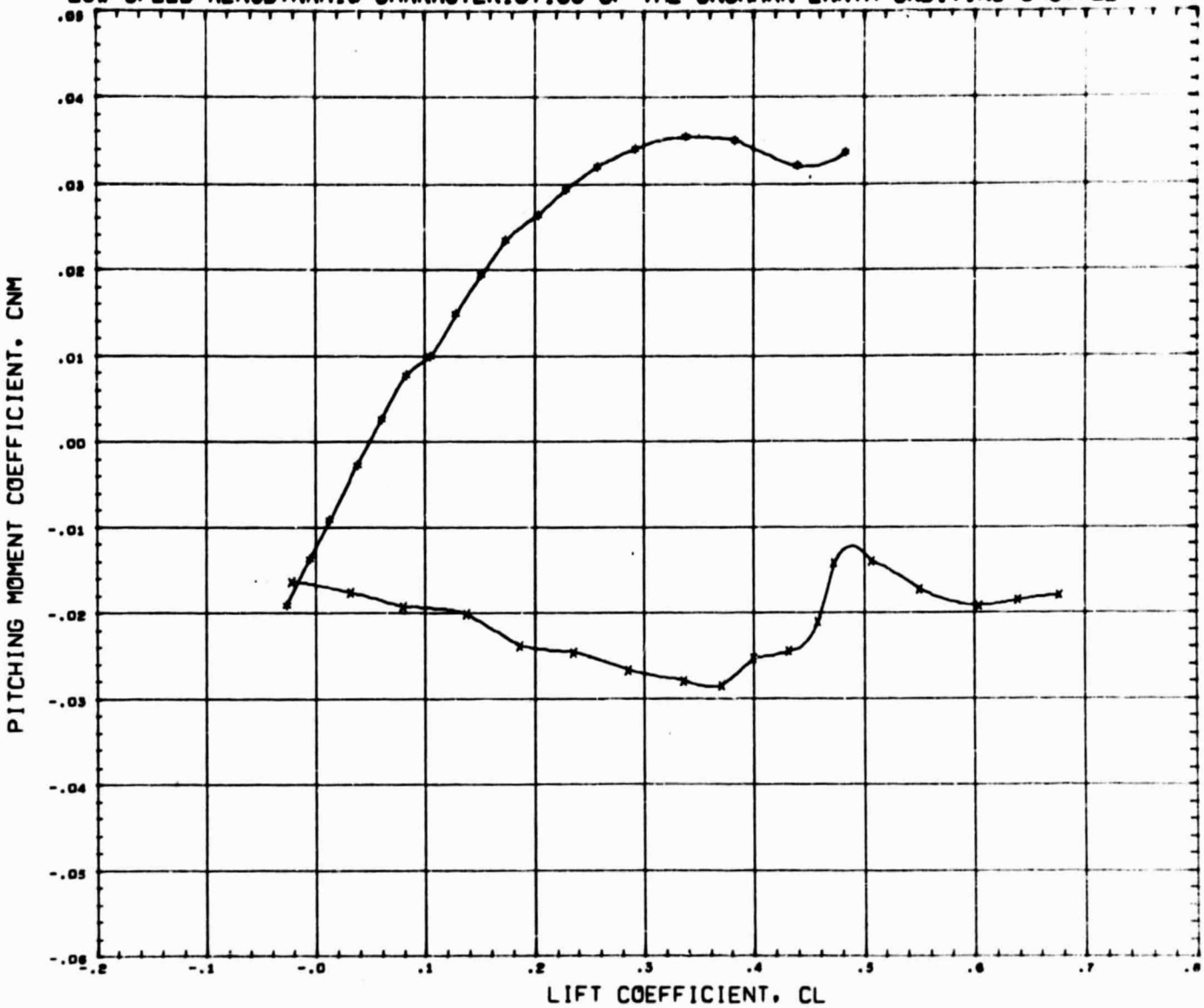
SYMBOL	CONFIGURATION DESCRIPTION	DATA SET	DATE	MACH
^	GWTT28D GAC EARTH ORBITER-B301N301	(RC3062)	13 JUL 70	0.200
X	GWTT28D GAC EARTH ORBITER-B301N301T1,50	(RC3022)	13 JUL 70	

REFERENCE INFORMATION

REFS	3.93750X10^{+00}	SQ.FT.
REFL	3.56250X10^{+00}	FT.
REFB	2.10000X10^{-01}	FT.
XMRP	6.90000X10^{+00}	FT.
YMRP	0.00000X10^{-02}	FT.
ZMRP	8.58000X10^{-02}	FT.
SCALE	2.50000X10	1/40TH

REFERENCE FILE

LOW SPEED AERODYNAMIC CHARACTERISTICS OF THE GRUMMAN EARTH ORBITING SHUTTLE



SYMBOL	CONFIGURATION DESCRIPTION	DATA SET	DATE	MACH
*	GWTT28D GAC EARTH ORBITER-B301N301	(RC3062)	13 JUL 70	0.200
X	GWTT28D GAC EARTH ORBITER-B301N301T1,50	(RC3022)	13 JUL 70	

REFERENCE INFORMATION

REFS	3.93750X10^{+00}	SQ.FT.
REFL	3.56250X10^{+00}	FT.
REFB	2.10000X10^{-01}	FT.
XMRP	6.90000X10^{+00}	FT.
YMRP	0.00000X10^{-02}	FT.
ZMRP	8.58000X10^{-02}	FT.
SCALE	2.50000X10	1/40TH

REFERENCE FILE